

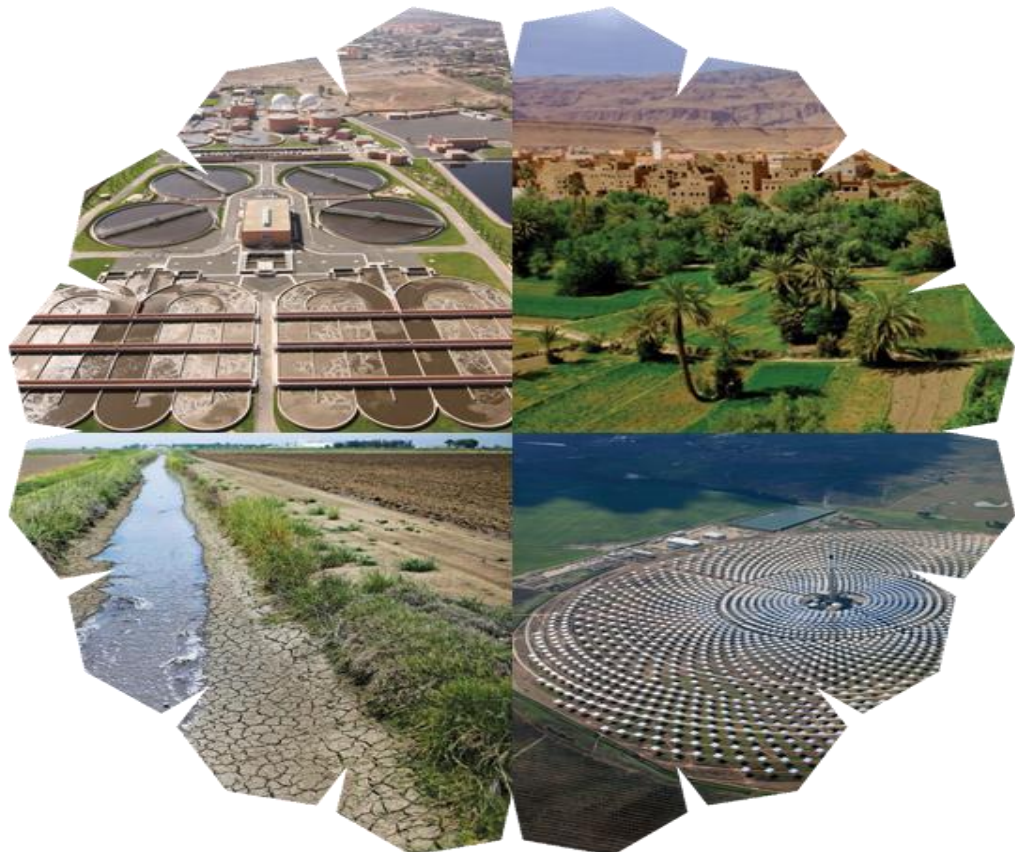


International Conference

WATER ENERGY & CLIMATE CHANGE

WECC2016

BOOK OF ABSTRACTS



PREFACE

The last 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in Paris witnessed a historical event. All nations have adopted, for the first time, a binding agreement to counter climate change consequences. This decision compels all countries to commit more seriously in order to achieve the target goal.

The city of Marrakech will be hosting the COP22 in November. It will be the opportunity for all nations to present first evaluation of the measures taken against global warming and greenhouse gas emissions. Morocco is really concerned by the consequences of climate change as it is located in an awfully vulnerable area. Hence, Morocco has adopted a directive law in its Environment and Sustainable Development National Chart to reduce its GHG emissions by 32% in the horizon of 2030.

On the occasion of the COP22, the National Center for Studies and Research on Water and Energy (CNEREE) of Cadi Ayyad University is organizing an International Conference on Water, Energy and Climate Change (WECC-2016). This conference will be held in partnerships with national and international research institutions and development stakeholders. The purpose of the WECC-2016 conference is to bring together researchers, engineers, practitioners, industrials, NGO representatives and decision making from all over the world to share, debate and disseminate innovative solutions and best practices in the fields of water and waste management, agriculture and food security, forestry, renewable energy and energy efficiency, adaptation and mitigation to meet climate related challenges.

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Plenary Conferences

ENERGY AND CLIMATE CHANGE: A KEY TO OUR FUTURE

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The energy system has powered economic growth worldwide, but is also the largest contributor to greenhouse gases emissions, generating about 2/3 of emissions. As a result, it is not only a big part of the climate change challenge, it must be a big part of the solution. Mr. Benoit will present IEA's work on understanding how we can reduce energy sector emissions while continuing to support global inclusive economic growth. In addition, water is not only a critical resource needed for energy production, but is also a resource that in turn will be affected by changes in climate; Mr. Benoit will also touch upon this energy/water/climate change dynamic.

ON THE USE OF REMOTE SENSING IN WATER CYCLE IN SEMI-ARID REGION IN THE CONTEXT OF CLIMATE CHANGE: RECENT ADVANCES AND FUTURE CHALLENGES

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The issue of climate change (present, past and future) and their impacts on environments, water natural resources, and human societies have been a matter of public concern and public policies. It becomes increasingly evident that the way of life of each individual affects the climate, and that climate affects the lives of everyone.

The perception and interest of global/regional climate change/variability are growing also in different scientific communities triggering innovative approaches, tools and funding. It becomes urgent to move forward their understanding on common modus operandi and importance of shared experiences both in terms of science and policy formulation for mitigation and adaptation.

Arid and semi-arid regions will face a strong impact of climate change in terms of water resources. There is thus a need to foster collaborative research, education and innovation program.

The objective of this presentation is to provide an overview of the issues of water resources research in arid and semi-arid region in several places in the world and to present the added value of using remote sensing data in conjunction with process models. Success stories and unsolved issues will be presented.

GLOBAL WARMING, NEW CLIMATE, NEW ATMOSPHERIC CIRCULATION AND NEW WATER CYCLE IN THE NORTH ATLANTIC OCEAN

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Global warming has now reached the energetic phase of H₂O's return to the ground after the saturation of the atmosphere in evaporation since the 80s and 90s of the last century, which were characterized by severe droughts, mainly in Africa.

This phase is the result of the accumulation of thermal energy exchanges in the Earth-Ocean-Atmosphere system that resulted in the thrust reversal of the energy balance toward the poles. This situation is characterized by a new thermal distribution: above the ocean, the situation is more in surplus compared to the mainland, or even opposite when the balance is negative on the land, and in the atmosphere, warm thermal advection easily reach the North Pole (planetary crests), as well as cold advection push deep into North Africa and the Gulf of Mexico (planetary valleys).

This "New Ground Energy Balance" establishes a "New Meridian Atmospheric Circulation (MAC)" with an undulating character throughout the year, including the winter characterized by intense latitudinal very active energy exchanges between the surplus areas (tropical) and the deficit (polar) on the one hand, and the atmosphere, the ocean and the continent on the other.

The excess radiation balance increases the potential evaporation of the atmosphere and provides a new geographical distribution of H₂O worldwide: the excess water vapor is easily converted by cold advection (polar vortex) to heavy rains that cause floods or snow storms that paralyze the normal functioning of human activities, which creates many difficulties for users and leaves damage and casualties, but ensures water availability missing since a long time in many parts of the world, in Africa, Europe and America.

The new thermal distribution reorganizes the geography of atmospheric pressure: the ocean energy concentration is transmitted directly to the atmosphere, and the excess torque is pushed northward. The Azores anticyclone is strengthened and is a global lock by the Atlantic ridge at Greenland, which imposes on the jet stream a positive ripple, very strongly marked poleward, bringing cosmic cold advection of polar air masses winter over from Europe to North Africa. Hence the enormous meridian heat exchanges north-south, and south-north.

This new spatial thermal provision therefore imposes on the jet-stream a positive ripple on the North Atlantic (Greenland) and eastern Pacific (Alaska); this is the cause of the heat and drought of California, followed by negative waves in eastern US, and Europe.

This is the "New Atmospheric Circulation" predominantly "Meridian", due to the "New Climate" caused by global warming.

FOSTERING PARTNERSHIPS FOR THE IMPLEMENTATION OF BEST AVAILABLE TECHNOLOGIES FOR WATER TREATMENT AND MANAGEMENT IN THE MEDITERRANEAN (FP7 PROJECT)

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FP4BATIW is a coordination and support action addressed to foster partnerships and networking aiming to implement the best available water treatment technologies in the MPC region by promoting the interaction between highly qualified members, both from EU and MPC, of the knowledge value chain on water treatment and corresponding stake holders community (national water agencies, municipalities, industrial waste water producers, entities managing business incubators, etc.) This action will lead to new approaches, tools and innovation, integrating sustainability aspects and allowing the collaboration between experienced and new teams for coaching and capacity building in cooperation and innovation. Such fostering activities will contribute to reduce the gap between research & innovation and the water treatment market enhancing synergies and allowing the concentration of efforts, know-how exchange, co-ownership and dialogue. FP4BATIW is founded over the activities carried out by several partners (13 members from EU and MPC) participating in different EU projects in the MPC region with a common central topic of water treatment technologies and the implementation of a platform of synergies around EU and MPC projects integrating water component for a capitalization, a concentration of the efforts and a maximization of the impacts and the resources (overcoming fragmentation and duplication and facilitating related TT). The regional cluster and cooperation activities that will be performed through 6 different work packages under FP4BATIW will provide additional links between research, technology enterprising and water users to enhance competitive research in water use efficiency. In this concern, 10% of the project budget has been earmarked for clustering activities to be organized with other on-going R2I projects targeting the MED region. These activities will be defined in coordination with the European Commission notably in the context of the International Learning Network (ILN), the idea will be to exchange information and best practices between the different projects and identify issues and possible activities of common interest in order to draft a roadmap for cooperation between the projects.

The continuous cluster cooperation will contribute to adopt the Mediterranean Water Strategy and related Action Plan that will provide the financial and instrument framework for the future, partnerships to create conditions for competitive research in water use efficiency, use of non-conventional waters, risk management and regional joint funding for trans-basin cooperation and regional water innovation programme. Indicated activities will ensure coordination with relevant actions engaged by the European Neighborhood and Partnership Instruments (ENPI), the Preparatory Action funded by the European Parliament and those implemented through the EIT and its Knowledge Innovation Centres including the Competitiveness and Innovation Framework Programme (CIP).

KEYWORDS: Water treatment; capacity building; water use efficiency; partnership; best practices

SCENARIOS FRAMING THE WATER-ENERGY-FOOD NEXUS CHALLENGES IN THE MEDITERRANEAN REGION

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INTRODUCTION

The water-food-energy nexus is a challenge in the Mediterranean area where the effect of climate change and unintended consequences of policies seeking to solve one part of the nexus end up worsening another. A nexus oriented approach meaning integration, inclusion, trans-sectoral vision as well as innovation is needed to understand the interlinkages and inter-dependencies across water, energy and food sectors through a holistic framework that takes into account the possible scenarios and explicitly defines interactions between systems and the effect one has on another. However, such interactions in the actual frame could be synergetics or antagonistic, and care must be taken to analyze the local circumstances in the handling of the three nexus components before defining possible actions with a nexus vision .

SCENARIO

FACTUAL SCENARIO FRAMING THE WATER-ENERGY-FOOD NEXUS CHALLENGES

Trends	Tensions	Transitions
<ul style="list-style-type: none"> Demographic increase Climate change impact Energy demands increase by 35% by 2035 becoming an important security issue. Photo-voltaic (PV) and wind technologies remain the least water-intensive electricity generation options. Critical water resilience threshold. Water demands increase at least by 20% by 2050 is becoming an important environmental and security issue. Food demands increase of about 70% by 2050 	<ul style="list-style-type: none"> Now 50% of human population is city dwellers, they will be 70% by 2050. Megacities will increase their number Demographic pressure Progressive resources scarcity and growing demand Need of economic development Changing lifestyle Changes in weather predictable environments Civil conflicts on resources and difficulties in law enforcement Security issues on the nexus components 	<ul style="list-style-type: none"> Political and social changes toward more participative approaches More stringent climate policy is necessary. Carbon Capture Storage (CCS) and biomass energy production will develop. Energy, water and food use and consumptions efficiency New models of agriculture for food security, water saving and waste uses Solar energy as a driver to cope with energy demand The NEXUS approach

However, these scenarios can be strongly affected by disruptive elements, such as the yet unknown impact of climate change, dietary changes or the actual Syrian refugees crisis, as

negative factors that could create new tensions and obstacles for the expected Transitions, but some other possible elements, such as saline and algae agriculture or development of nanotechnologies in water treatments can be positive disruptive factors.

CONCLUSION

1. It is imperative to understand the trends and impact of climate change and the demographic evolution in the different world regions.
2. Mitigation actions using the NEXUS approach require avoiding the parceling of the political and administrative responsibilities.
3. Water or energy shortages affect food production leading to social instabilities which derive in political conflicts.
4. The pace of knowledge creation and transfer about the NEXUS issues must be increased.

KEY WORDS: Water-Energy-Food Nexus, Scenarios, Synergies, Conflicting actions

HOW PAUWES COULD CONTRIBUTE TO CAPACITY BUILDING FOR SUSTAINABLE WATER AND ENERGY MANAGEMENT IN HIGHER EDUCATION IN AFRICA

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The Pan African University (PAU) is a priority Education project of the Commission of the African Union, and since 2008, has been endorsed at the highest political levels decisions of the Summit of Heads of State and Government of the African Union. The PAU aims to promote network and develop programs and research centres within selected existing high quality universities in the five geographic sub-regions. North Africa region, Algeria hosted the PAU Institute on Water and Energy including Climate Change (PAUWES) which will be committed to select and to network high quality centres developing similar programs and to serve as a coordinating hub for those institutions.

PAUWES has a specific responsibility and assigned role to implement research programmes identified in the water and energy sciences, technologies and innovation strategy for Africa (STISA-2024) published by the African Union. This highlights the Pan Africanism of the Institution and its role in contributing to a lasting change in Africa in the area of climate change policies and strategy. Given PAUWES focus on water, energy and climate change sectors, the institute is in position to provide expert insight and research on these vital areas of the continent. In particular, it will consider ways to facilitate much greater innovation, entrepreneurship and technology transfer that could raise the quality of applied research and higher education in Africa.

Ultimately, the institute's underlying aspiration and role is the train students, equipping team with the skills that need to translate ideas into reality. PAUWES is building the next generation of scientists and policy makers who will support and shape Africa's policymaking in water, energy and climate change. PAUWES is working with prestigious regional and international Institutions to lead the training of post-doctorate candidates, doctorate and master's students to undertake research relevant to water and energy sciences development in the continent. In this regard PAUWES will use regional and international programmes and networking as key mechanisms for supporting MSc/PhD and training across African and MENA regions on areas related to water engineering and policy expertise and development.

The experience of PAUWES cooperation, in educational and scientific activities and capacity building initiatives relating, with high level leading universities and Institutions in Germany and Africa was shared by exchange of academic staff, researchers and students, undertaking joint research and teaching activities, organizing of and starting collaborative research activities and internships.

Dissemination is very important issue of PAUWES, and it was carried out through a set of actions carried out by the PAUWES community of practice. It aims at enhancing the visibility of the partners, get in touch with major stakeholders in water and energy sector and explore further collaboration opportunities in join research projects or public private partnerships.

Along the way PAUWES encountered operational and coordination challenges and the necessity to merge also different approaches to achieve the broader scope of the Institute. We report here our experience, the obtained results, lesson learnt and our directions for the future.

ORAL PRESENTATIONS

Topic 1

Water sustainability and climate change

WATER RESOURCES IN ALGERIA: SCENARIOS, PROJECTED STRATEGIES ON 2030-2050 IN VIEW OF CLIMATIC CHANGES

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INTRODUCTION

Water is a precious resource and a common property; that is why, the climate change issue represents a serious threat to limited and unequally distributed natural resources both quantitatively and qualitatively. Besides, the environmental dimension of climate change is drawing attention to that big question which considers water likely to be a generator of peace! In fact, all GIEC links and relations accord an important place to water and put in first place, the influence of climate on water resources and the increase of risks [1], and according to the WHO, it is high time to react as the climate changes impacts do not only affect water resources, but also diseases and food safety ... In this study, we are going to analyze the projected effects of Climate change on Algerian Water resources on 2030- 2050 and try to find the suitable strategies to face them in order to reach sustainable development.

MAIN RESULTS

In our research, we first created a strategic model for simulation Politique des ressources en EAU (Water resources politics) « SISTRAP-EAU » which simplifies both long and short term predictive simulation of scenarios and presents other benefits such as: water resources evaluation, development parameters, demographic evolution, Climate change impacts, decision taking tools, parametric model...etc, Its operating fits into the sustainable development aspect [2].

We came up with three scenarios; the first one « Trend scenario » where we took as hypotheses all the parameters of the current water resources situation without having recourse to water saving. The second one « The voluntarism scenario » where the hypotheses were: Water economy, Water resources mobilization and a better management; the results though remain unpleasing.

In the third one « Climatic Change Scenario », we treated two simulation types projected on 2030 and 2050 which are: Climatic change impact on water resources « Trend scenario» and « Voluntarism scenario». The obtained results are disastrous.

We made the whole interpretation of the results and projected using a strategic action plan and considering international cooperation for extenuation of greenhouse gases, a political voluntarism, and a better organization and new strategy in order to reach sustainable development which requires to equate social and economic preoccupations with environmental preoccupations considering the factor of necessity and scarcity, namely water

resources[2]. A deeper comprehension of climate characteristics and an efficient modelization of the impacts of extreme events, rainfall and temperature fluctuations are all meant to give us the ability a quicker evaluation of the consequences on water cycle [3].

CONCLUSION

According to the pessimistic results of this study, Algeria from 2030 to 2050 is facing a serious dilemma in the water domain and the perfect solution centers on the strategy we are proposing and that we are going to expose, but also on a dialogue and a cooperation between countries (south/north & south/south) and supporting the innovation for an economic growth in energy and in greenhouse gases emissions and this in order to contribute to food and energy security and preserve water resources. Water is a resource of sustainable development, the core of tomorrow's main issues and climate changes are imposing to humanity to reduce emissions and establish adaptation politics and a wider cooperation [4].

KEYWORDS: Water Resources, Scenarios, Projected Strategies, Climatic Changes

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ASSESSMENT OF CLIMATE VARIABILITY AND IMPACTS ON HYDRO-CLIMATE PARAMETERS (RAINFALL VARIATION IN GROMBALIA BASIN, TUNISIA)

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INTRODUCTION

In the recent years, the main challenge assessed by researchers is to have a better understanding about climate change. Rainfall variation is one of the essential climatic factors responsible for climate change and requisite to be studied systematically.

The object of this study is to assess the recent past and present climate as well as climate change in Grombalia basin. The rainfall measurements since 1980 have been analyzed, on different spatial and temporal scales, in order to find out whether there have already been trends and whether the behaviour of rainfall has changed in time.

We focus on assessing trends and variability in rainfall. Mann-Kendall trend analysis and Sen's slope estimator are used in determining the changes in the rainfall climatology. The study is based on a set of methods concerning trend as well as on statistical methods for detection of breaks in time series.

MAIN RESULTS

Rainfall Index

The goal is to examine rainfall variability in semi-arid region, to investigate these results for signs of climate change. An attempt has been made to analyze long-term rainfall data obtained from rain gauges (Barrage el masri, Soliman CTV, Grombalia DRE and Beni khaled FI-I...).

We deal with annual precipitation level as observed in Grombalia, mainly during 1980 to 2014. The rainfall index showed an irregular space time distribution of rainfall and an inter-annual variability was marked by wet and dry year's fluctuations.

Rainfall trend

To identify the trend in this climatic variable, the Mann-Kendall [1,2] test has been used by a number of researchers. In this study, the nonparametric Mann-Kendall test was applied to determine monotonic trends in rainy data.

The annual rainfall in Grombalia has shown different trends depending on the station. The trend line fitted to each station rainfall observations can serve to identify the general characteristics of each season as well as inter annual variability of rainfall. Fig. 1 shows the slope of the trend lines for an example of an analyzed stations.

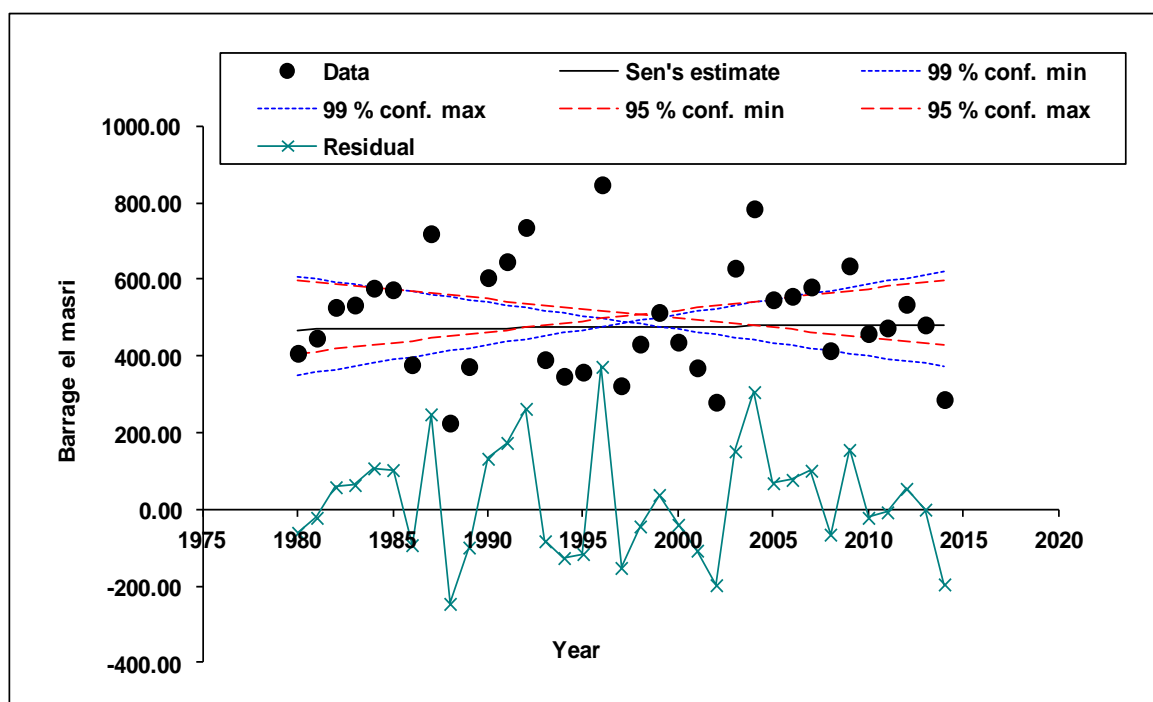


Figure 1. Result of Kendall test

Results show that in the past 34 years, changes in precipitation regime could be observed. The methodology highlights some breaks in time series. Also, it reveals a variability of rainfall regimes in the so-called semi arid region of Tunisia.

References

- [1] Kendall M.G, 1975, Rank Correlation Measures. Charles Griffin. pp 202
- [2] Mann H. B, Econometrica, 13, 1945, Non-parametric tests against trend. pp. 245–25

THE DAM RESERVOIR OF BIN EL OUIDANE (AZILAL, MOROCCO) FACE TO CLIMATE CHANGE

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Introduction

Morocco opted earlier, since the 60s, for a dynamic and anticipative water policy, based essentially on building and exploitation of large reservoir dams. The aim was to satisfy the rising demand on drinking water, irrigation and hydroelectricity, in order to assure his development. This Policy has helped to face the water scarcity and hydro-climatic irregularity related to Climate Change (CC), which characterize the Maghreb region in the last decades. The CC is a reality and will continue in the next decades, with various impacts especially on the water sector. The Maghreb region seems to be particularly exposed to this risk according the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5).

In the aim of preparing the managers of these dams to a new management mode of their reservoirs, that considers the potential impacts of CC, and to suggest appropriate approaches and methods, it's important to analyze the hydro-climatic behavior of these reservoirs during the last century, and to deduct a first assessment. This correspond to the objective of the present communication applied to Bin El Ouidane Dam, located in the region of Azilal (Morocco). In this research, we try to analyze the climatic and hydrologic behavior in this reservoir, and the water management practiced during the past decades (1939-2013) and to deduct the trends that might help in future projections.

Main Results

This analysis was based on complete data for water supplies to the dam (1939-2013), and limited data for air temperature (1989-2013) and rainfall/evaporation (1976-2013). These data were measured in the Bin El Ouidane Dam (for management variables, evaporation rate and water supplies), the Tilouguite station upstream of the reservoir (for temperature, rainfall and evaporation rate) and in dam upstream station of Ait Ouchène (for rainfall).

The climate behavior in the region during the last decades, resulting from this analysis, follows the global trends described in the IPCC AR5: A continue accelerated climate warming, associated to a high evaporation, a global decrease of rainfall, characterized by an alternation of dry and wet periods and even sometimes very wet periods, as it's the case in Morocco since years, and a deficit rainfall balance.

The reservoir water management has followed this hydro-climatic cycle, with assignments of water for irrigation that depend on the amount of rainfall in each year. This water allocation has increased in general, considering the high rising of water demand required for the agricultural development of the Tadla-Azilal.

In addition, this analysis helped to show how the hydro-climatic context had evolved around the Bin El Ouidane Dam, for more than 70 years, with water supplies diminution in the period after 1975/76, compared to the period before. It's important to mention that between these two periods, a change was also identified in terms of water supplies intra-annual evolution. The period before 1975/76 was characterized by a delay, of at least one month, in the first significant winter water supplies and a reduction of the rainfall duration, from 7 months (December to June) to 5 months (January to May). This change can be explained in

part by a change in the hydrologic behavior of the watershed upstream the dam, which loose progressively its pluvio-nival regime, to a regime much more pluvial, because of the decrease of snowfall precipitations in relation with global warming. This observation confirms the conclusions of the IPCC AR5, concerning the diminution of snow surfaces in high altitudes

Concerning the water management in this reservoir, it was made reactively, and might be much more efficient, if the CC hasn't started to destabilize the climate of the region and its hydrologic system.

Conclusion

The anticipation in term of reservoir management, based on historic hydrologic and climate data, will become less and less possible. So, the use of climate and hydrologic models, to forecast the future rainfall and water supplies is recommended, as it was initiated in some large dams around the world. It's the key of success of any sustainable reservoir management, in the context of water scarcity characterizing the region.

KEYWORDS: dam; Bin El Ouidane; climate; change; management.

SOIL MOISTURE AND DROUGHT MONITORING IN MOROCCO DURING THE TWO LAST YEARS USING REMOTE SENSING

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Soil moisture is a key factor in climate and hydrology; it impacts the heat and mass transfers between soil and atmosphere. Moreover, it plays a fundamental role in the partitioning of precipitation into infiltration and runoff and the partitioning of incoming radiation into sensible and latent heat. Thus, Soil moisture is a key variable in land surface and atmospheric systems, and has been identified as one of the “Essential Climate Variables”. The term soil moisture refers to the amount of water in the upper layer of soil that interacts with atmosphere. It can be expressed in different units but the most common is the volumetric soil moisture. This variable can be measured in a variety of ways from the simple gravimetric technique to more complex electronic instruments. The choice of a particular method depends on the application and the resources availability. Unfortunately, it's important to realize that in the local scale the retrieval of soil moisture is available by the in-situ measurement using one of these all methods. But, information access in the regional or global scale and in sufficient time series is more complicated which usually leads to a rough estimate, or completely disregard of this parameter. Such a response on this problem is that the global soil moisture mapping is now feasible thanks to the microwave remote sensing. Indeed, Microwave sensors respond to the amount of water in the soil especially for lower frequencies since the large dielectric constant of water at lower microwave frequencies causes a large change in emissivity of soils. In this context, soil moisture satellite was launched in 2009 by the European Space Agency (SMOS: Soil Moisture & Ocean Salinity). As the most promising data source of soil moisture mapping in different spatial and temporal scales, SMOS data is chosen to be used in this work, in the one hand.

In the other hand, the current climate change is a very complex phenomenon, it is essential to refine the information on climate change in a country likely to be negatively impacted by global warming, such as Morocco in recent years. The recent decades have seen a growing interest in the projections of future climate and the effects on water resources as a means to identify appropriate adaptation strategies. Droughts and floods are extreme climate events that percentage-wise are likely to change more rapidly than the mean climate. In order to monitor droughts and wet spells and to study their variability, numerous specialized indices have been devised using readily available data such as precipitation and temperature. The Palmer Drought Severity Index (PDSI) is the most prominent index of meteorological drought used. The PDSI is a standardized measure of surface moisture conditions that allows comparisons across regions and time.

Thus, the aim of this paper is firstly to analyze the spatio-temporal variation of soil moisture in Morocco site during two successive years 2014 and 2015. For that, get access

to the Level 3 SM data and its downloading was the initial step, the data format was converted from NetCDF to Geotiff format, then the first soil moisture mapping of the study area is established for each month of 2014 and 2015. Next, for each climate zone area in Morocco; the temporal soil moisture values were compared by drawing the graph line of soil moisture variability in this period and generating differences maps. Secondly, Palmer Drought Severity Index (PDSI) is calculated in chosen areas of Morocco and then compared to the soil moisture changes.

KEYWORDS: Climate change; Soil Moisture; Drought; Morocco; SMOS; Temperature; Precipitation; PDSI

CLIMATE CHANGE IMPACTS ON THE HYDROLOGY OF MEDITERRANEAN BASINS – QUANTIFYING UNCERTAINTY AND RISK

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The Mediterranean region is experiencing a broad range of threats to water security. According to latest climate projections, as published in the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013) or the European Environmental Agency (EEA 2012), the region is at risk due to its pronounced susceptibility to changes in the hydrological budget and extremes, which is expected to have strong negative impact on the management of water resources and on key strategic sectors of regional economies. However, the current potential to develop appropriate regional adaptation measures towards climate change impacts suffers heavily from large uncertainties.

The EU-FP7 funded project CLIMB (Climate Induced changes on the hydrology of Mediterranean basins) put a major focus on the assessment and quantification of uncertainties in climate change impacts, related vulnerabilities and risk, by means of a comprehensive multi-model ensemble approach. In its 4-year design, a network of 20 partners from 9 countries, analyzed ongoing and future climate induced changes in hydrological budgets and extremes across the Mediterranean and neighboring regions. The work plan was focused on seven circum-Mediterranean river or aquifer systems, where the consortium employed a novel combination of field monitoring and remote sensing, data assimilation, integrated hydrologic modeling and socioeconomic factor analyses targeted to reduce existing uncertainties in climate change impact analysis.

Advanced climate scenario analysis was utilized and available ensembles of regional climate model simulations were audited and downscaled. This process provided the drivers for an ensemble of hydrological models with different degrees of complexity in terms of process description and level of integration, identifying a clear climate change signal for all test sites with a strong increase in temperature and a general decline in precipitation for the southern case studies. An earlier onset and an increased duration of the dry season in the summer months is likely to increase pressure on the water resources and aquifers in the areas. These changes demand for increased irrigation of agricultural areas to maintain the current production. Thus, longer dry seasons and lower recharge rates of the ground water systems indicate a higher vulnerability of agricultural productivity and food security in the areas. The results of hydrological modeling and socio-economic factor analysis were applied to develop a risk model via a spatial Vulnerability and Risk Assessment Tool, serving as a platform for dissemination of project results, including communication and planning for local and regional stakeholders, namely the CLIMBPortal. An important output of the research in the individual study sites is the development of recommendations for an improved monitoring and modeling strategy for climate change impact assessment.

The results from CLIMB largely confirm, but specify on the catchment scale the current state of the art on climate change research for the Mediterranean region, demonstrating that climate change is impacting water resources in a manifold and distinct fashion. Triggered mostly by a strong increase in temperature and a moderate to strong reduction and seasonal re-distribution of precipitation, impacts will mostly be felt in water resources management, agriculture, tourism and its consequent implications on income, value-at-risk and water

security under increasing water scarcity. Selected results indicate that i) climate change contributes, yet in strong regional variation, to water scarcity in the Mediterranean; other factors, e.g. pollution or poor management practices are regionally still dominant, ii) rain-fed agriculture needs to adapt to seasonal changes; stable or increasing productivity likely depends on additional irrigation, iii) tourism could benefit in shoulder seasons, but may expect income losses in the summer peak season due to increasing heat stress, iv) local & regional water managers and water users, lack, as yet, awareness of climate change induced risks, with emerging focus areas are supplies of domestic drinking water, irrigation, hydro-power and livestock, and, v) data and knowledge gaps in climate change impact and risk assessment are wide-spread and ask for coordinated monitoring programs. Site-specific recommendations for adaptation to climate change have been developed in a dialogue with local and regional stakeholder networks and were collected in a Policy Position Paper.

However, while substantial progress has been made, uncertainties in climate projections and subsequent (hydrological) impact assessment remain and still impose strong limitations on water-related decision-making under conditions of climate change. This is particularly true due to the general lack of regional data and the yet unresolved mismatch of spatial and temporal scales of operation from different scientific perspectives.

KEYWORDS: CLIMB; Mediterranean; water scarcity; climate change; hydrology; vulnerability; risk analysis

Acknowledgement:

The funding for this research through the FP7-project CLIMB by the European Commission (GA:244151) is gratefully acknowledged.

TRADE-OFFS BETWEEN ECOSYSTEM SERVICES AND HYDROPOWER GENERATION, CASE OF THE AKOSOMBO AND KPONG DAMS, GHANA

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Water infrastructure development has proven to be linked to economic development in many countries. In Africa, there is a great push towards investments in water infrastructure to boost economic growth. However, dam construction and management has an impact on the natural environment and livelihoods that depend on it, through upstream impoundment and downstream altered flow regime. Restoring and/or considering downstream livelihoods' dependence on the natural flow regime for dam operation and management, may create trade-offs between these users and the formal uses, such as the agriculture and hydropower sectors. This paper describes an effort to incorporate the ecosystem services into the planning of reservoir operation and management for the Akosombo and Kpong dams, and to provide lessons learnt for other dams in Africa.

The Akosombo dam was constructed in 1966 to produce hydropower for the Aluminum processing plant. Since then the power generation of the dam has contributed significantly to the economic development of Ghana and the region. Kpong dam was constructed in the early 80s and augmented the energy production of the Akosombo dam. Due to the construction of these dams and their operations towards optimizing hydropower production, the flows to the Lower Volta floodplains and into the Delta have changed dramatically. Four restoration hydrographs were developed based on literature review, expert judgements and fieldwork (consultations and measurements).

The impact of supplying these restoration hydrographs on hydropower production and other downstream users was assessed using the WEAP model. The results show that increasing the environmental flow requirements to a more naturalized flow regime (reintroducing natural flow dynamics upto a certain level) reduces the hydropower production by 23%, and only 75% of the irrigation requirement is being supplied to the irrigation system. Increasing the natural flow dynamics to levels that are similar to the average historical flows reduces the hydropower production by almost 26%, and impacts the supply to irrigation areas by more than 70%, in particular affecting the dry season production. For these scenarios, a significant amount of water is spilled unproductively during the wet season, reducing water stored in the reservoir, affecting electricity production and water releases for irrigation during the dry season.

Climate change scenarios (A1b and A2) project significant reduction in rainfall over the Volta basin. Hydropower production in the BAU scenario is reduced by 54%. Providing the natural peakflows to the Lower Volta is increasingly difficult while the provision of natural

low flows comes at limited expenses to the hydropower development (additional reduction of 32%) in the dry season. Providing restoration hydrographs to the downstream communities under climate change, in particular the peakflows therefore is increasingly difficult. Because of the relative importance of hydropower generation in the Lower Volta to Ghana and the region, reduction in power generation to supply water to downstream communities will be difficult at the national level. However, similar approaches and studies could inform the management and operations of other hydropower dams of less significance, in particular the ones that are in the planning phase, such as Pwalugu multi-purpose dam in northern Ghana.

KEYWORDS: Dam Reoperation, Volta Basin, Climate Change, Ecosystem Services, Hydropower

Acknowledgement

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NET CHANGE: HARVESTING FOG FOR RESILIENCE IN SOUTHWEST MOROCCO

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Introduction:

Dar Si Hmad for Development, Education and Culture (DSH) runs one of the world's largest fog collection systems. After a decade-long experimental phase, the project was officially inaugurated in 2015 and now pipes potable running water into the homes of five rural villages in the Anti-Atlas Mountains of Southwest Morocco. Incorporating from its outset user-centric planning and embracing the interrelation between justice, livelihoods, and sustainability, the fog project serves as a case study for the potential of holistic development.

Main Results:

One of the saddest realities of climate change is its unequal impact. Already marginalized communities “bear the brunt of environmental degradation” [1]. Vulnerable populations and fragile landscapes intersect to further jeopardize livelihoods. Recognizing this, Dar Si Hmad's fog project is guided by principles of environmental justice, purposefully integrating gendered and pro-poor analyses to generate maximum impact. On their own, fog collection nets are an innovative technological solution to water stress and the environmental uncertainties wrought by climate change, an ancient idea revitalized for modern demands in fog dense areas [2]. By leveraging the trust built over the course of the project's feasibility study, Dar Si Hmad has built a comprehensive development program delivering not only potable water but also literacy and numeracy support, capacity building, and STEM-based education to some of Morocco's most at-risk villages.

Women hold an ancestral role as water guardians in much of the world. Building from ICCD models linking ICT, climate change, and development [3], Dar Si Hmad created a fog monitoring system valorizing this role. Literacy and numeracy trainings in partner villages enable women to govern household supply via SMS message. Expanded literacy capacities have proven useful for much more than capturing fog data, demonstrating the mutual benefits of engaging beneficiaries in the planning and implementation of development projects [4].

Prior to the fog water inauguration, women in partner villages spent up to four hours collecting water every day. Fog water is creating a *de facto* equality of time between the sexes. To ensure women are able to use the newfound time in ways that benefit them and mitigate the potential negative impacts of alterations to local gender norms, a series of capacity building trainings explored agricultural co-operatives as routes to economic empowerment. Sustainable, locally led businesses further boost resilience as communities have access to multiple income sources.

Complementing adult education is the Water School, a hands-on curriculum engaging area youth around issues of water, sustainability, and conservation. Activities combine art, engineering, science, and math to teach societal and natural realities, equipping rural youth to be makers rather than victims of global change.

Additional spin-off projects include WASH trainings improving community health; the installation of eco-friendly toilets reducing disease and helping retain girls in schools; and a fog water fed reforestation program engaging new stakeholders.

Successfully navigating the water, energy, and climate change nexus requires creative approaches to adaptation and development. Dar Si Hmad's fog harvesting project is one such holistic project that might serve as a pedagogical blueprint for applied resilience projects.

KEYWORDS: fog harvesting; water; sustainable development; women's empowerment; environmental education

References:

- [1] L Hansen and J Kerr, "The Justice of Water Conservation: NGOs and Civil Society", *Proceedings of Environmental Justice and Global Citizenship*, 2010
- [2] Vicky Marzol, *La captación del agua de la niebla en la isla de Tenerife*, Caja Canarias: Santa Cruz de Tenerife, 2003
- [3] R Heeks and AV Ospina, "ICTs, Climate Change and Development: Themes and Strategic Actions », Centre for Development Informatics, 2012
- [4] Leslie Dodson, *A Foggy Desert: Equitable Information Flow for a Fogwater System in Southwest Morocco*, University of Colorado Boulder, 2014

ADAPTATION OF A MEDITERRANEAN COASTAL URBAN RIVER BASIN TO PRECIPITATION PATTERNS CHANGES: A SOCIO-ECONOMIC APPROACH

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Climatic Change (CC) is nowadays one of the most influent drivers for the modification of existing water-related patterns, and social and environmental structures, especially in the coastline. Considering the Climatic Change (CC), a change of rain patterns is expected in the Mediterranean, mainly in the sense of modified precipitation models and less in terms of total quantity along the years. More storm events are predicted, capable of delivering important amounts of water in short periods. Although this is a usual characteristic of the humid and sub-humid Mediterranean areas, it seems that the rainfall intensity will increase combined with extended periods of drought.

The present study deals with the influence of the change of the precipitation patterns at the end of a river basin in a heavily populated area (Besòs basin in the Greater Barcelona Metropolitan area) in the Spanish Mediterranean coastline. The Besòs is a small river, located in the northern part of the Greater Barcelona. Its basin is relatively small (100 km²) and its location near a heavily populated and industrialized area marked its characteristics: heavy pollution of water, banks and bed. The urbanized area, heavily populated, surrounds the last 10 km of the river, with housing developments, industries and several communication infrastructures (railways, roads, motorways) occupying the laterals.

Like other Mediterranean rivers, the Besòs can present heavy sudden flows due to intense precipitations, short but enough to create an unfavorable concentration of the runoff. The highest flow register was over 2,000 m³/s while the usual flow rarely exceeds 10 m³/s and an important part is treated wastewater.

The former river consisted of an alluvial plain of around 300 m width, progressively occupied in the 20th century by any type of constructions and infrastructures. Due to a disaster caused by an extraordinary flow in the year 1962, with many casualties, the riverbed was modified, building a concrete infrastructure: a 130 m width channel with lateral walls capable to hold extraordinary flows up to 2400 m³/s. The low flow concrete canal was 20 m width and completely straight.

From 1980 on, wastewater treatment plants were built and the river water quality improved dramatically. At the end of the 90's the neighboring population and municipalities decided to improve the river system through several actuaciones. In the year 1999 the Metropolitan authorities, partly funded by EU funds committed a restoration procedure, with the aim to recover the final part of the river. The riverbed was cleaned - in depth and surface -, a tertiary treatment system for treated wastewater was built inside the bed, and a fluvial park consisting of a grass planted area capable to host leisure activities was implemented.

From the social point of view, the project was a real success and the neighbors quickly started to use the park. Due to its success, the project continued with two additional phases reaching the river mouth and involving two municipalities, which did not participate in the initial phase.

At present, and after the success of the project, it seems necessary to evaluate from an economic and social point of view the features and results of the river modification. It is to consider that CC-related new conditions, mainly from the point of view of precipitation new models and seawater level changes could exert an influence on the success of the project in the mid-term.

From the legal point of view, several rules and regulations and its application to the area considered including the terms in relation to the CC, must be carefully studied. The Water Framework, the Floods and the Dangerous Substances Directives (European Union) are to be considered, as well as the Spanish Water Law and the Royal Decree on Floods. There are also some regional rules, which must be followed.

From the socio-economical point of view, a cost-benefit analysis is absolutely necessary in order to know the social evaluation of that project and the additional measures to face the CC. The main items for this calculation are in terms of: a) the improvement of the quality of life (health, water quality, places for leisure activities, tourism – bird watching) of the neighbors and other stakeholders; b) environment (better water quality, new green infrastructures, recovered habitats for flora and fauna; c) increased price of the real estate/properties.

The economic tools suggested are: hedonic pricing, contingent valuation, travel cost, market value. Additionally, a prospective study in terms of changes due to CC uses the results for the estimation of the adaptation costs to be incurred.

The CC scenarios defined by the international organizations and applied to the local characteristics are the basis for the present work.

KEYWORDS: Climate Change, Coastal Areas, Interface sea-river; Socio-economic valuation, Mediterranean

SUSTAINABLE WATER MANAGEMENT SYSTEM: THE CASE OF DOHA

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More countries across the world are facing water supply challenges due to population growth and increased urbanization, there is an ever increasing demand for freshwater. However, in many countries including Qatar, drought and depleted and contaminated groundwater supplies are creating water scarcity. Doha is the capital of Qatar, a small peninsula on the northeasterly coast of the larger Arabian Peninsula. The Qatari peninsula extends 100 miles (161 km) north into the Persian Gulf from Saudi Arabia.

Much of the country consists of low sand covered plains. The climate of Qatar can be described as a subtropical dry, hot desert climate with low annual rainfall, very high temperatures in summer and a significant difference between maximum and minimum temperatures, especially in the inland areas. The coastal areas are moderately influenced by the Persian Gulf, and have lower maximum, but higher minimum temperatures and a higher moisture percentage in the air. Most rain falls during the winter months in short, heavy thunderstorms. Annual precipitation is less than 100mm per year while evaporation rates are in excess of 2000mm per year, creating a water deficit.

The population of Qatar, particularly Doha, is still increasing and water consumption per person is amongst the highest in the World; in excess of 500 litres/person/day. To put this into perspective, in many European countries it is circa 150 litres/person/day or less. To overcome this challenge Qatar has invested in the use of desalination to produce freshwater for potable use. Seawater is desalinated through a costly energy-intensive thermal process that has many environmental impacts. The consumption of so much water creates large quantities of domestic and industrial waste water. Where the infrastructure exists, domestic wastewater is collected, treated and reused primarily for irrigation of public open spaces and highways.

As a modern city, Doha has many green accessible public open spaces with highway central reservations, traffic islands and kerbs being planted with a wide variety of native and non-native annual and perennial flora and fauna.

Treated sewage effluent (TSE) is used to irrigate these areas, typically using drip feed methods, spray irrigation or hand held hose systems. One of the main risks associated with these systems is the health risk to the public and in particular to the labour force installing and maintaining these areas. The TSE is treated to a tertiary level and can still contain some harmful bacteria and micro-organisms within the small aerosol water particles.

This paper looks at an alternative method of providing TSE irrigation from a shallow subterranean storage system. Recycled polypropylene geocellular units are linked together to form a structural raft and then partially wrapped in an impermeable geomembrane to form a storage tank. The cells incorporate columns of a highly absorbent rockwool and the top of the raft is covered in a needle-punched wicking geotextile that helps distribute the TSE on demand into the growing medium. The cells are not fully filled with TSE and incorporate an air zone which provides oxygen to the growing medium. The paper examines how TSE can be used in a more effective and economic way taking into account the local climatic conditions along with the social and public health concerns related to the use of treated sewage effluent.

KEYWORDS: freshwater; water scarcity; Treated Sewage Effluent (TSE); irrigation; subterranean

MODELING OF PERMEABILITY IN A SEMI-ARID REGION IN THE CHOICE OF THE BEST SITES SUITABLE FOR THE PLACEMENT OF ARTIFICIAL UNDERGROUND TANKS: APPLICATION TO THE PLAIN OF SAÏSS (NORTHERN MOROCCO)

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Artificial recharge of aquifers from rainwater or treated wastewater has become a very convenient answer that helps replenish the reserves in the duration of aquifers, including those affected by overexploitation. Via its accentuated exploitation for domestic reasons, agriculture and industry, the Pliocene-Quaternary water table of the plain of Saïss suffers from a decrease in groundwater supplies. And the significance of rain water in semi-arid to arid, it was necessary to remedy this situation by building underground dams and hill lakes as promised technological tools of management and conservation of water tends underground than the trickling namely their essential role as the main system of artificial recharge of aquifers. The work presented in this paper focuses on to identify, using a geographic information system (GIS), more favorable zones of permeability aside for construction of underground dams and reservoirs search sites retention and storage of surface waters geomorphological side, for their development in the form of small lakes. Thing that will guarantee a better infiltration of surface water into the groundwater and certainly ensure the objective of improving their artificial recharge and sustainable conservation of groundwater resources in the plain. The method is, in fact, to develop a geographic database while specifying the topic on geological, hydrological and hydrogeological specific to the study area. Treatment data reveals the existence of two zones of average permeability and four other high permeabilities endowed with an important hydrographic density; these can be used as holding tanks to the surface, and also may be considered as favorable sites for equipment with underground dams.

Keywords: Groundwater, plain of Saïss, underground dams, hill lakes, GIS, artificial recharge

CLIMATE CHANGE VULNERABILITY: SHARED AQUIFERS CASE STUDY: GCC DAMMAM SHARED GROUNDWATER AQUIFER

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Gulf countries have been experiencing different degrees of natural and anthropogenic water risk affecting the sustainability of their limited water resources and preservation of the ecosystem equilibrium. The fragile arid environment and its resiliency to cope with external natural and anthropogenic activities, including the expected impacts of climate change, present a major challenge to decision-makers who must achieve adequate, safe and dependable water and food supply in the future to improve human well-being in their societies, and to meet the requirements of future generations. It is expected that climate change will impose further stresses on the limited freshwater resources in Gulf countries and intensify their vulnerability. This is of particular concern for those countries relying on shared water resources, which in the absence of sharing agreements will increase tensions between riparian countries. In this study, the expected environmental impacts on shared water resources from water depletion, pollution and climate change are evaluated for the non-renewable Dammam aquifer. The Dammam aquifer is shared among Saudi Arabia, Kuwait, Bahrain, Qatar, UAE, and Oman. The vulnerability index (VI) was estimated for the shared sources, taking into consideration the climate change impacts that may modify the rainfall regime in the West Asia region and impact on the water availability stress (RS), development pressure (DP), ecological health (EH) and management capacity (MS).

The study concluded that the issue of shared water resources should be given high priority by GCC countries to finalize water resources sharing agreements according to international water laws. Large water savings opportunities exist in the agricultural sector where most water wastage occurs. Savings are possible by increasing irrigation efficiency with the introduction of enhanced irrigation and agricultural techniques, reuse of treated wastewater, augmentation by agricultural drainage water, and the implementation of incentive/disincentive systems.

KEYWORDS: Shared groundwater vulnerabilty, climate change and management of shared groiundwater, regional cooperation

MAPPING SPATIAL DISTRIBUTION OF CHEMICAL ELEMENTS OF GROUNDWATER IN A SEMI-ARID ZONE

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Water quality analysis is one of the more important issues in groundwater studies. The hydrogeochemical study reveals the zones and quality of water that are suitable for drinking, agricultural and industrial purposes. Further, it is possible to understand the change in quality due to rock water interaction or any type of anthropogenic influence. Groundwater often consists of seven major chemical elements Ca^{+2} , Mg^{+2} , Na^+ , K^+ , Cl^- , HCO_3^- and SO_4^{-2} . Hence, hydrogeochemical studies can be conducted by analyzing water samples based on these components. The study area for the present work is the Ghriss plain plio-quadernary aquifer located in the north-west part of Algeria. In the present study, 48 samples were collected during the month of November 2005 from wells situated in different part of the plain. The purposes of this investigation were to provide an overview of groundwater quality and to determine spatial distribution of the major ions and salinity expressed by TDS. An interpolation technique, ordinary kriging, was used to obtain the spatial distribution of groundwater major ions elements and TDS. The resulting maps were analyzed and discussed taking account firstly the geological and structural specificity on each part of the study area, secondly the hydrodynamic parameters controlling the groundwater flow and thirdly the impact of human activities on groundwater quality. Over than 60% and 75% of the samples have a concentration of Cl^- and TDS exceeding WHO (World Health organization) standards of 250 mg/L and 1000 mg/L, respectively. The highest concentrations of TDS, Cl^- , Na^+ are located in the north-east of the Ghriss plain. Indeed, in this region, the dissolution of salt formations as halite contained in the wall of the aquifer (Miocene marls) and the reconcentrations of ions in the unsaturated zone by evaporation are mainly and simultaneously causes of the high salinity of the groundwater at this level. The presence of sulfate ions in water is related to the dissolution of gypsum formations or the use of some fertilizers including those intended for viticulture. The highest concentrations of sulfate are located in the north part of the plain where the gypsum marls outcrops in the BeniChougrane Hills. The concentrations of nitrates in the groundwater remain below the potability standard of the WHO estimated at 50 mg/L. Contaminated water by nitrates were observed especially downstream of the two large cities of the region namely Mascara and Tighennif. The southern part of the plain is also contaminated by nitrates. The low permeability of geological formations at this level associated with intensive use of fertilizers may explain the observed excess of nitrates in this part. According to WHO standards, wells located between the cities SidiKadaMatemore and Maoussa, are suitable for drinking water. The synthesis of the maps representing spatial distribution of the chemical ions shows that this region has the optimum groundwater quality. "Clean" waters in this zone are especially coming from the recharge by

the karstic aquifer in the south east. The results obtained gave the necessity of making the public, local administrator to be aware on the poor groundwater quality prevailing in the area. The good quality groundwater must be preserved from any contamination especially by agricultural activities.

KEYWORDS: Groundwater quality, Major Ions, Spatial Distribution Mapping, Ghriss Plain Aquifer.

CONTRIBUTION OF GIS AND GEO-STATISTICAL TOOLS IN THE READAPTATION OF ESTIMATING FLOOD PEAKS' METHODS TO CURRENT CLIMATE SITUATION

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Introduction

The readaptation of the methods used to estimate flood peaks in order to size hydraulic structures has become necessary to prevent the damages caused by recent extreme events on these structures. Hydrometeorological and empirical methods are among the most used methods for estimating flood peaks in sizing purpose in Morocco for dams, bridges, road crossing.... Both methods are based on regional parameters which values alter greatly the results obtained.

So the aim of this study is to calculate with accuracy the regional parameters used in these methods for the Tensift basin using GIS and geo-statistical tools. For empirical methods, processing the digital terrain model of the study area resulted in delineating watersheds, tracing the river system and calculating all parameters necessary for the characterization [1]. For hydrometeorological methods namely Gradex method and rational method, we developed an accurate mapping of the Gradex parameter and Montana parameters (registered at rainfall stations) using the geostatistical method of kriging. These maps can give the values of these parameters at any given point (the site of a project) [2].

Main Results

The Tensift watershed is located in the western center of Morocco surrounding the city of Marrakech. It stretches for over 19400 Km² and is drained by the Tensift River that flows from east to west for over 260Km.

The first step for the rehabilitation of flood peak estimating methods was the determination of the structural parameters and network flow parameters used in most of these methods. To do this we used the extension ArcHydro of the software Arcgis to process a DEM SRTM with a resolution of 90m [3]. The use of GIS tools has helped calculate with great precision structural and morphological parameters of each of the 19 sub basins delineated. Such as surfaces of sub basins (from 40.7 Km² to 19549 km²) and perimeters (from 38.7Km to 1078.4Km) and average altitudes of sub basins (from 35m to 4123m). This work therefore, has shown a great heterogeneity for the Tensift basin.

Rehabilitation of hydrometeorological method was performed by creating the cartography of Gradex values and Montana coefficients calculated at the rainfall stations spread over the Tensift basin. Spatial interpolation was carried out by the geostatistical method of kriging. This method was chosen because it has the advantage of taking into account the spatial interdependence and quantifies prediction standard errors associated with predicted values unlike the conventional interpolation methods. Two kriging models were tested with and without a trend. Several reference functions (exponential model and spherical nugget) were used for modeling the variogram. Cross-validation has enabled a comparison of the results of these models. The best model helped to develop maps for the values of Gradex of 24h rain, as

well as those of Montana parameters for return periods of 2, 5, 10, 20, 50 and 100 years. Prediction standard error maps associated with the predicted values have also been developed, [2].

Conclusion

GIS tools and geostatistical tools are to be used in hydrology for better estimation of certain parameters. Reading the map Gradex shows that risks of highest rainfall increase in moving from the center of the basin to the east and west so upstream and downstream of the basin. These results show, due to the use of rain 24h, the location of the rather slow floods whose propagation time may range to several days. However it is necessary to develop maps based on the data of rain with duration of less than 24 hours (1 hour to 12) to be able to see the flood risk in mountain areas. Indeed, the high slopes in these areas makes flood characterized by lower concentration times.

References

- [1] Ahattab, J., Serhir, N., & Lakhal, E.K.. 2015. Vers l'élaboration d'un système d'aide à la décision pour le choix des méthodes d'estimation des débits max des crues : Réadaptation aux données hydrogéologiques récentes. *Revue Internationale de l'Eau, La houille Blanche*, section SimHe, n° 1, 2015, p. 63-70.
- [2] Ahattab, J., Serhir, N., & Lakhal, E. K. (2014). Mapping Gradex values on the Tensift basin (Morocco). *Int. Journal of Engineering Research and Applications* , 5 (4), 1-7.
- [3] Jarvis A [et al.] Hole-filled seamless SRTM [Online] // <http://srtm.csi.cgiar.org>. - International Centre for Tropical Agriculture (CIAT), 2008.

Keywords: readaptation; flood peak estimating method; climate change; Arcgis, kriging, Map; Gradex; Montana coefficients; Tensift.

DEVELOPMENT OF INTEGRATED SCENARIOS TO ASSESS FUTURE CONDITIONS OF AQUATIC ECOSYSTEMS UNDER WATER SCARCITY IN THE MEDITERRANEAN– PERSPECTIVES FROM THE GLOBAQUA PROJECT

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Water and water-related services are major components of the human wellbeing, and as such are major factors of socio-economic development; yet freshwater systems are under threat by a variety of stressors (organic and inorganic pollution, geomorphological alterations, land cover change, water abstraction, invasive species and pathogens).

Water scarcity is most commonly associated with inappropriate water management and resulting river flow reductions. It has become one of the most important drivers of change in freshwater ecosystems. Conjoint occurrence of a myriad of stressors (chemical, geomorphological, biological) under water scarcity will produce novel and unfamiliar synergies and most likely very pronounced effects. Stressors are hierarchically arranged in terms of intensity, frequency and scale, and their effects can be predicted to be from transient to irreversible. Most ecosystems are simultaneously exposed to multiple-stress situations.

Within the scope of the GLOBAQUA project the effects of multiple stressors on aquatic ecosystems in selected river basins across Europe with a focus on areas suffering from water scarcity are analyzed. In addition, management strategies are improved and adapted with the aim of inhibiting adverse effects on aquatic ecosystems and ensuring the supply with water for all purposes in the study areas also in the future. Policy relevant implications will be given to ensure a best possible status of these aquatic ecosystems also under future conditions. In this context, land use and land cover as well as the meteorological conditions can be seen as two main stressors for the quality and quantity of surface and subsurface water. These factors considerably affect the use and availability of water, especially in regions which already experience water scarcity. If the problem is not addressed correctly, negative effects on biodiversity, water supply as well as important economic consequences may arise. In Europe, many fresh water systems experience this and a worsening of the situation can be expected if actions are not taken. To assess future conditions, spatially distributed, integrated scenarios to drive various impact models are inevitable. These simulations then assess future conditions of aquatic ecosystems, both in water quality and quantity, and in the end provide decision support.

To achieve this goal, a modeling framework is set up to develop integrated scenarios of changes in climate, land use and water management. These scenarios are based on storylines around various Representative Concentration Pathways (RCPs) and Shared Socio-economic Pathways (SSPs), as established by the Intergovernmental Panel on Climate Change (IPCC), and developed in collaboration with project partners and experts. Major challenges stem from the downscaling of these to the regional scale.

Projections of future climate conditions originate from the simulations provided through the EURO-CORDEX project. An ensemble of different General Circulation Models (GCMs) driving various Regional Climate Models (RCMs) is available. After a thorough investigation of these projections and an estimation of the uncertainty envelope, a small subset of models was chosen in a carefully conducted selection procedure, following a cluster analysis. These

selected simulations were downscaled to better represent the regional conditions and provide the implications of the RCPs in the storylines.

The impacts of the SSPs are represented in spatially distributed land use maps developed through the land use change model iCLUE (Conversion of Land Use and its Effects). In a first step knowledge on past land use change is required and an analysis was carried out based on the CORINE land cover data. Extensive expert surveys have been conducted in the case study areas to determine the most important drivers of these changes, considering both, biophysical and socio-economic variables. The results of these were implemented in iCLUE taking into account dynamic changes of the climate, population and economy.

Climate and land use projections will then be applied to provide possible future conditions and various impact modeling activities within the GLOBAQUA project. This approach is favored over a non-integrated approach using only climate projections, and required to develop and test site specific Programs of Measures (PoMs). Eventually, decision support can be provided to local authorities for effective PoMs.

KEYWORDS: GLOBAQUA; Mediterranean; water scarcity; climate change; hydrology; integrated scenarios;iCLUE; EURO-CORDEX;

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ASSESSMENT OF THE SUSTAINABILITY OF THE WATER SECTOR MANAGEMENT SYSTEM IN BAHRAIN

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Situated in one of the most arid regions of the world, the Kingdom of Bahrain has extremely poor endowment of water resources, and taking population into consideration under these climatic settings, the kingdom has one of the lowest per capita freshwater availability in the world, and is considered one of the world's most water-stressed countries; due to rapid population growth per capita freshwater share has been continuously declining. Worse still, and without taking into account the future impacts of climate change, the per capita freshwater availability is expected to fall by more than half in the next two decades if Bahrain current population trends continue. However, the causes of scarcity of water in the Kingdom is not only limited to the natural conditions and increase in population, but also to the low water efficiency of the water management system in both the supply and the demand sides.

The fast growth rate in population and the associated development processes, represented by rapid urbanization, expansion of irrigated agriculture and industrialization, in the last four decades have brought about substantial water demands increases. To meet rising demands, water authorities have focused their efforts mainly on the development and supply augmentation aspects of water resources management. Sectoral water demands are being satisfied by groundwater abstraction, installation of desalination plants, and expansion in wastewater treatment and reuse. These efforts, particularly the expansion in desalination plants and treated wastewater reuse, have improved the per capita water share considerably. However, the adoption of the supply augmentation approach without giving adequate attention to the aspects of demand management, water efficiency, and conservation have led to the emergence of a number of unsustainable conditions, such as low water use efficiency, growing of per capita water use, escalating sectoral water demands, large percentages of non-revenue water and low cost recovery, increasing costs of water production and distribution, deterioration of water quality, and many other conditions that impact the overall sustainability of the water management system in Bahrain. Under these conditions, the heavy financial, economic, and environmental costs, as well as social costs and burden to be borne cannot be overemphasized for a country with limited natural and financial resources like Bahrain. It is expected that climate change will further aggravate the water situation in Bahrain and impose further stress on the water management system in the country and increase its challenges.

In this research, a country-wide assessment of the impacts of climate change on the water resources system in Bahrain (i.e., vulnerability) is made, with particular focus on the municipal water sector. Moreover, the most appropriate management interventions to enhance the sustainability of the water management system (i.e., adaptation) are proposed. The vulnerability assessment and the effectiveness of the management interventions for adaptation were made by using dynamic mathematical model (WEAP dynamic modeling system) representing and simulating the dynamics of the water sector components in Bahrain.

Keywords: climate change; vulnerability; adaptation; supply-demand gap; efficiency; WEAP.

WATER SECTOR MANAGEMENT VIA-INTEGRATED WATER RESOURCES MANAGEMENT APPROACH AND ADAPTATION TO CLIMATE CHANGE IMPACT IN THE ARABIAN PENINSULA REGION

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The Arabian Peninsula region (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen), its arid and extreme arid climate, un-sustained consumption patterns and recently climate change phenomena have been impacting water availability and its sustainability. The unprecedented developmental activities since early 1970s to meet the MDG goals of water supply, sanitation, food requirements and pollution control have placed substantial stress on the already limited renewable and non-renewable sources. Water availability was further stressed by the un-sustainable water consumption patterns and the natural random variability of rainfall and run off amount including climate change impact on the weather events specially extreme event. Water availabilities in 2014 were estimated at 15.7 billion cubic meter (bcm) in comparison to water demand of 32 bcm and projected to reach 40 bcm and 2025 respectively have resulted in increased utilization of the renewable sources and depletion of the non-renewable groundwater sources and increased pollution levels. During the last three decades the water sector was managed by implementing policies that have focused on short term supply development with limited and fragmented demand management measures. In this paper, each country's existing water-policy components, challenges, and constraints, is discussed within the framework Integrated Water Resources Management (IWRM) approach and adaptation to climate change impact. The issues of balancing supply with demand, climate change vulnerability to supply, the enhancement of water governance (coordination, updating administrative and legal framework, dissemination of information and participatory process) and needed programs to improve the performance of the water sector will be addressed. The paper will focus on meeting the basic water supply, sanitation and food SDG targets, risk management, good governance, valuing water, role of society and regional cooperation. All these issues will be addressed within the IWRM framework taking into consideration the arid, extreme natural physical, social, cultural setting with emphases on water scarcity, climate change vulnerability, sustainability the situation will be further retreated unless appropriate management measures are put in place.

Keywords: Arabian Peninsula, IWRM, water resources management. Climate change impact, water stress vulnerability

USE OF REMOTE SENSING FOR REGIONAL ESTIMATION OF EVAPOTRANSPIRATION IN THE KAIROUAN PLAIN. COMPARISON WITH LARGE APERTURE SCINTILLOMETER MEASUREMENTS

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Evapotranspiration is one of the most important fluxes of the water balance in semi-arid areas where water availability is a major limitation for agricultural production; it is a key factor for optimizing irrigation water management. The estimation of evapotranspiration on a regional scale may be possible using remotely sensed inputs for crop water balance models. These models can benefit from remote sensing since the latter provides periodic information about the vegetation development which is a primary factor driving evapotranspiration. In this study, spatially distributed estimates of ET over an irrigated area located in the Kairouan plain (Central Tunisia) were computed using the SAMIR tool (SATellite Monitoring of IRrigation), based on the coupling of the FAO-56 dual crop coefficient model with time series of high resolution NDVI imagery (Normalized Difference Vegetation Index) providing estimates of the actual basal crop coefficient (K_{cb}) and the vegetation fraction cover (f_c). The objective of the work was to assess the SAMIR operationality and the accuracy of the modeled evapotranspiration at perimeter scale, in a context of high land cover complexity (i.e. trees, winter cereals, summer vegetables) and limited data available for parameterization. The model was calibrated on the basis of local ET measurements from flux towers (eddy-correlation devices) installed on irrigated wheat and barley plots. For other crops for which no calibration data was available, parameters were taken from bibliography. In a subsequent step, half hourly evapotranspiration measurements were obtained using a large aperture scintillometer (LAS) over the study area along a pathlength of 4 Km and were used to validate SAMIR's evapotranspiration estimates. Daily modeled evapotranspiration were compared to latent heat flux (ET) returned as a residual term of the surface energy budget using the daily scintillometer's sensible heat flux measurements and net radiation (computed using instantaneous MODIS data and then extrapolated to daily time step).

KEYWORDS: Remote sensing, water balance, FAO-56, evapotranspiration, scintillometer

HYDROGEOLOGICAL CHARACTERIZATION BY THE MRS SURVEY OF THE FISSURED BLEIDA AQUIFER (ANTI-ATLAS – MOROCCO)

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Morocco's water resources are facing challenges of rarefaction. Our study area, which is the Bleida region belonging to the buttonhole Bou Azzer in the Anti-Atlas, is not immune to this phenomenon. Indeed, the climate is semi-arid and water resources both ground and surface are so limited, on the one hand, due to the fractured nature of the terrain and on the other hand due to the progressive succession of drought years.

In front of this problem, a good knowledge of water potential should be conducted to require the development of an adequate exploitation plan at this region. This knowledge is only possible with a reliable characterization of the hydrogeology of the area and its potential groundwater resources.

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The fractured aquifer of Bleida is not well studied in hydrological terms, it is true that he was the subject of several geophysical studies, but his characterization was up for mining purposes.

Our study intervenes in this case to improve the hydrogeological knowledge of the aquifer through the magnetic resonance sounding (MRS or RMP).

This study purpose the application of the method of magnetic resonance sounding in view to provide answers to the questions relating to the issue of water resources in the region Bleida. Its aims the identification of areas favorable to the establishment of productive hydraulic drilling.

To this goal, eight surveys of magnetic resonance sounding were conducted at two sites, separated by 300 meters, to the intersection between the faults, the results of this recognition are:

- The first site showed a saturation of up to 14% in the first eight meters, explained by the drained water from the dam. Saturation decreases further by going in depth.
- The second site showed a maximum of 6% saturation levels ranging between 50 meters and 71 meters.

Both of those sites show two horizons of saturation, having the following characteristics:

→ 1stHorizon:

- Water content 11%;
- Relaxation time T2* 300-600 ms ;
- Permeability 2.1 E- 03 à 8 E-03 m/s ;
- Transmissivity 3.3 E – 03 à 3.2 E - 02 m²/s.

→ 2edHorizon:

- Water content 11%;
- Relaxation time $T2^*$ 100-600 ms ;
- Permeability $5.9 \text{ E}-04$ à $4.2 \text{ E}-03$ m/s ;
- Transmissivity 2.3 E^{-02} à 2 E^{-01} m²/s.

The remarkable permeability variation may be the result in this ground shale to the variation of the crack state. Decreased permeability in fractured medium can be translated by the clogging or closing of cracks. While an increase may be due to the interconnection of multiple cracks or meet a major fault.

Both sites are investigated further 290 meters separated by a river show variable degree of saturation in the same levels. Finally we were able to raise the reliability of the RMP method in the presence of the boundary conditions of its use by correlating the results of surveys with existing boreholes. Moreover we locate a place for the implementation of a productive drilling.

KEYWORDS: MRS survey; water content; hydrogeological knowledge; Bleida.

IMPACT OF CLIMATE CHANGE ON GROUNDWATER RESOURCES IN MOROCCO: THE CASE OF THE LOUKKOS BASIN

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INTRODUCTION

The coastal aquifer system of Rmel is recognized as one of the most important aquifers in Morocco that could be affected by salinization in the coastal fringe. This aquifer is located in the North-West part of Morocco and very well known for its role that is playing in industrial, economic and social development. The average of rainfall ranges from 1121 mm/y in 1963 to 508 mm/y in 2014 and the impacts of climate change in the Loukkos basin in north-western of Morocco cause the recurrent droughts and decreases in recharge that directly affect the groundwater level. This phenomena is coupled with heavy abstraction rates ranging from 9 million (M) m³ in 1963 to 16.4 Mm³ in 2014 from the Rmel aquifer system which is used for industrial and drinking water supply either for rural and urban areas, and irrigation of an area of 14025 Ha. This situation has led to a major decline in the groundwater levels and may eventually cause a water balance deficit of the system as well as a degradation of the freshwater quality by seawater intrusion on the coast and the coastal plains of the study area (303km²). Hence, effective management of groundwater resources in this aquifer system is necessary and can be made by developing a computer model that allows us to understand the conditions that govern the behavior of freshwater/saltwater transition zone in the coastal aquifer subject to the various input conditions, and to test management scenarios based on various economic assumptions. The best scenario will be presented to the regional water resources authorities for the recommended economic and water resources planning and development.

MAIN RESULTS

The hydrogeology of the Rmel coastal aquifer consists of plio–quaternary sands and sandstone, but the bottom is composed of blue marls [1]. To better understand the aquifer reservoir, a 3D Geoscientific Information System (3D GSIS) was elaborated for processing, viewing and analyzing data; showing the hydrogeological structure, the extension and geometry of the reservoir and the conceptual model.

This GSIS database product was integrated into a Geographic Information System (GIS) developed through a local database. Then a geostatistical model was realized and integrated into the GIS. The normality test and the analysis of trends were studied for each variable to select the appropriate variogram and check the results using cross-validation.

This product of GIS database has led to assess the water balance, based on a soil-water balance equation, and was defined as the difference between the inflows (rainfall, irrigation) and the outflows (pumping, natural flow).

A three-dimensional numerical groundwater flow model, calibrated under steady state (Fig. 1) and transient variable density groundwater flow and solute transport for a period from 1963 to 2014, was developed by means of the Visual Modflow based on SEAWAT code [2]. It is used to predict the drawdown and the hydraulic head in the aquifer system for the period ranging from 2014 to 2030 under three different groundwater management scenarios and to give the water balance within time.

Database, water balance and hydrological modelling play a crucial role and we had much to gain in incorporating these modelling results in GIS by developing a Visual BASIC application for this case study. The results, findings and policy implications of this study may help managers of the Rmel aquifer to prioritize areas that are most sensitive to coupled human activities and climate change and variability, and implement best management practices in the context of adaptability and long-term sustainability of groundwater resources.

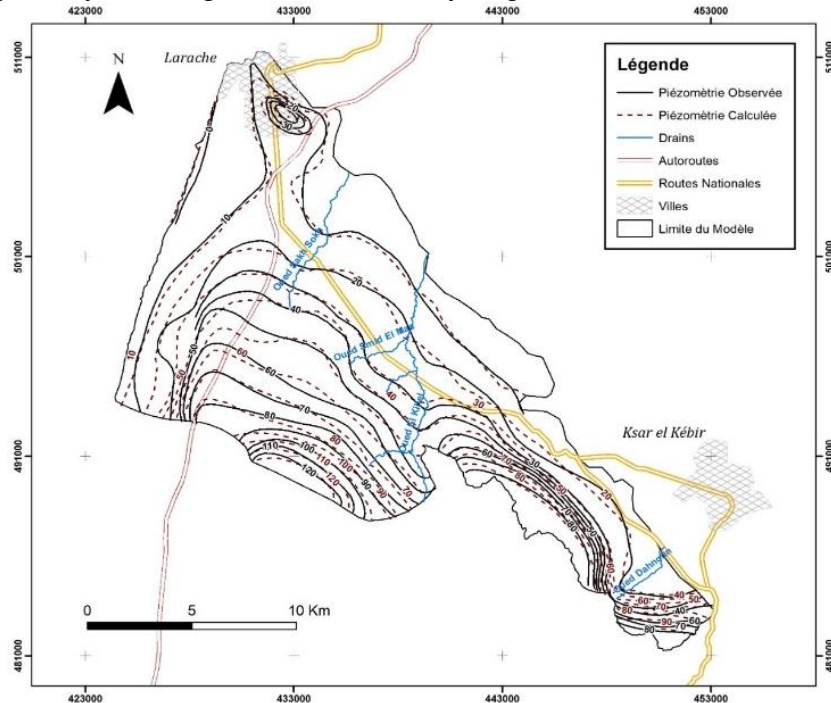


Figure1. Calibration model in steady state (in 1963)

Acknowledgement

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References

- [1] Bentayeb A., Etude hydrogéologique de la nappe côtière de Rmel avec essai de simulation mathématique en régime permanent. Thèse Univ. Scien. Tech. du Languedoc, Montpellier, 1972.
- [2] Guo W. et Langevin C.D., User's Guide to SEAWAT, A computer program for simulation of three-dimensional variable density groundwater flow. U.S Geological Survey, Tallahassee, Florida. Open-File Report 01-434, 2002, pp. 1-77.

ESTIMATION OF EVAPOTRANSPIRATION OF IRRIGATED CROPS IN MEDITERRANEAN SEMI-ARID AREA: REMOTE SENSING AND MODELISATION

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Morocco is a country mainly (93% of total area) arid and semi-arid. These climatic conditions (low rainfall and high evaporation) make irrigation a key technical requirement that the social and economic benefits are undeniable. Especially in the agricultural domain, which occupies 14% of Gross Domestic Product (GDP) in Morocco (L'agriculture Marocaine en Chiffre, 2012). While Irrigation is very consuming of water; it is estimated that about 85% of the available resources is used by agriculture (Plan Bleu, 2009). While the available water resources are scarce and the area is already declared as a "hot spot" of climate change in several reports of the IPCC. In this situation, a rational and sustainable management of irrigation water is needed. This requires an accurate estimation of crop water needs (equivalent to crop evapotranspiration) of irrigated agriculture.

Over the last decades, several methods have been developed for measurement crop evapotranspiration (ET). The direct measurements such as: Bowen ratio (Bowen, 1926), Eddy covariance system (Running and al., 1999), Scintillometer (Green and al. 2000), Lysimeter (Howell et al., 1995), but they are expensive and difficult to deploy and maintain in both time and space. Another option is provided by simulation models according to their complexity: FAO-56 (Allen and al., 1998), Two Source Energy Balance (TSEB, Norman et al. 1995), Soil water monitoring (SEtHyS, Coudert and al. 2006), Multidisciplinary simulator for standard crops (STICS, Brisson et al. 1998)... benefiting from the availability of remote sensing data for a large-scale application.

The objective of this work was to test the validity of two different approaches to estimate actual evapotranspiration: an energy budget model TSEB and an empirical model FAO-56 through the Satellite Monitoring of Irrigation software (SAMIR) (Simonneaux et al. 2007). Both approaches are based on: (1) use of optical and thermal remote sensing data with a high resolution scale (SPOT-5 and ASTER): vegetation index (NDVI) and surface temperature, (2) field observations: leaf area (LAI), land use, air temperature and humidity, wind speed, solar radiation and precipitation. The field measurements were performed over an irrigated area (mainly of wheat) located in the Haouz plain, 40 km East of Marrakech (Central Morocco). The obtained results (Fig. 1) showed that both models estimate correctly ET in comparison with the results obtained by the method of Eddy-Covariance. The Root Mean Square Error (RMSE) was 0.45 and 0.51 mm/day for FAO-56 and TSEB, respectively. This correlation is very well marked at periods when one observes an increase of evapotranspiration according to the quantity of water brought by irrigation. . In conclusion, both models offer good ability to reproduce the seasonal cycle of evapotranspiration and foresee the prospects of use to aid irrigation management.

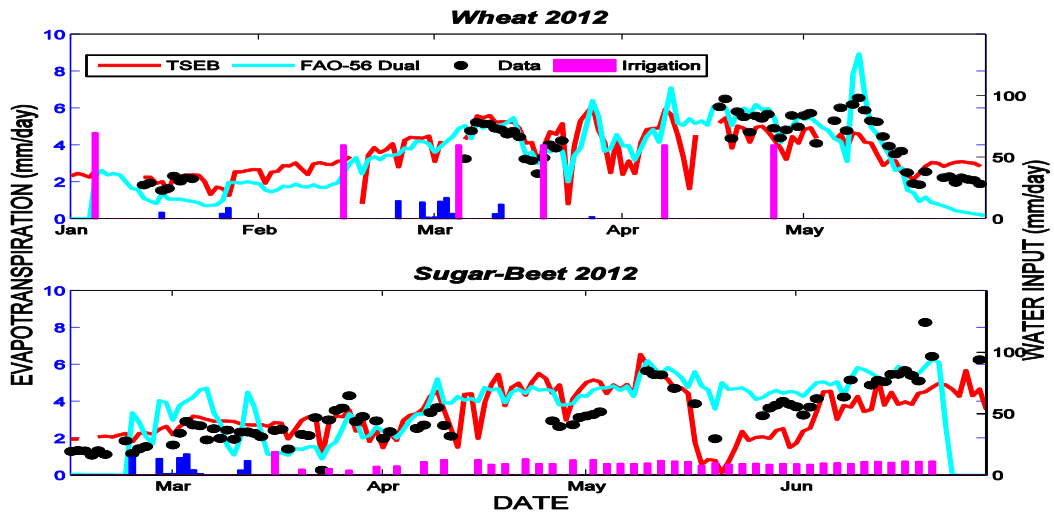


Figure 1: Seasonal cycle of evapotranspiration of 2012 agricultural growing season

Keywords: Irrigation; Agriculture; Water management; Evapotranspiration; Remote Sensing.

Topic 2

Advances in Water treatment, recycling and reuse

CONSTRUCTED WETLANDS: A TOOL FOR DIFFERENT STRENGTH WASTEWATER TREATMENT

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Constructed wetlands (CW) are considered a wastewater treatment tool adaptable to diverse types of wastewater, from low strength (e.g. tertiary treatment of urban wastewater) to high-strength ones (e.g. pig slurry) as well as for dehydrating and treating wastewater sludge. Recently, CWs have been applied for the treatment of wastewater from different activities (agriculture, industrial, landfill leachate, etc.). The specific characteristics of those wastewaters (new pollutants, extreme concentrations, low biodegradability, high toxicity) are a challenge for the application of CWs, and further research is necessary to optimize their design, operation and adaptation to the real circumstances.

The aim of this paper is to examine the viability of subsurface flow constructed wetlands (SSFCWs) for the treatment of wastewater derived from three different sources (treatment ponds, pig farms and car wash facilities), and to evaluate the influence of design and operational parameters on treatment efficiency (physico-chemical and microbiological parameters and new pollutants) and hydraulic behavior. The studies were done in the framework of different national and European R+D projects. The viability of horizontal subsurface flow constructed wetlands (HFCWs) and vertical subsurface flow constructed wetlands (VFCWs) to treat the effluent from wastewater treatment pond systems (for discharge or reuse) was evaluated in the framework of MEDIWAT (1G-MED09-262) project in a municipal wastewater treatment plant in Santa Eugènia (Mallorca, Spain). The viability of hybrid SSFCW to treat swine slurry from the small farm Can Corominas in Viver i Serrateix (Barcelona, Spain) for land application or discharge was evaluated in the framework of CTM2010-19197 and MEDIWAT projects. Finally, the viability of HFCW and VFCW to treat the effluent from car wash facilities for recycling at a station located in Montfullà (Girona, Spain), using an infiltration-percolation system as reference, was evaluated in the framework of MinAqua project (LIFE11-ENV-569).

The pond effluent was characterised by a large quantity of algae and high variability that depends on environmental factors (temperature and solar irradiance). The experimental results demonstrated the effectiveness of HFCWs and VFCWs to upgrade pond effluent quality by retaining algae and suspended solids, completing organic matter degradation, and nitrifying the pond effluent in the case of vertical flow and partially removing total nitrogen in the case of horizontal flow. Retention of phosphorus was overall very low. The filtering media size (sand or gravel) was the key parameter for algae retention.

On the other hand, pig slurry presented high concentrations of suspended solids, organic matter, nitrogen and phosphorus, with high variability. The hybrid configuration, which combines VFCW and HFCW, had a dual function for simultaneous solid-liquid separation and biological treatment. Removal of organic matter and suspended solids was very high, while the overall nitrogen load removal was 63%, due to the combined nitrification/denitrification

processes. VFCW were operated intermittently and with sequential feeding, achieving good hydraulic performance with no clogging problems, despite high pollutant loads. Some of the pollutants were retained and mineralized in the surface deposit layer, increasing around 20 cm each year. This organic biosolid layer improved filtration efficiency. The high ammonia contents interfered with the growth of *Phragmites australis*, while the high concentration of suspended solids and organic matter also limited the type of SSFCW to be implemented.

Finally, car wash effluent had a high concentration of inorganic suspended solids, very variable concentrations of *E. coli* and organic matter, low concentrations of nutrients, and the presence of hydrocarbons, fats and oils. The effluent presented non-ionic surfactants, but at lower concentrations than expected due to high biodegradability and low dosing of the detergents used in the facility. The three technologies evaluated performed very efficiently with respect to turbidity, organic matter and suspended solids. Non-ionic detergents, hydrocarbons, fats and oils were also completely removed, but their concentrations in the influent were already low. *E. coli* was removed to acceptable limits for recycling. The oil and fats contents of the car wash effluents as well as the inorganic suspended solids made pre-treatment necessary in order to avoid media clogging.

SSFCWs have proved to be a sustainable and efficient technical solution to treat small wastewater flows with special characteristics. These technologies have shown resilience to load and hydraulic fluctuations, to new pollutants and to variable environmental conditions; being simple to operate and maintain with null or minimum energy requirements and with an added aesthetical value.

KEYWORDS: wastewater treatment and reuse; natural technologies; constructed wetlands; ponds; industrial and agricultural wastewaters

LONG TERM TREATMENT PERFORMANCE OF CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT IN MOUNTAIN AREAS: CASE STUDY FROM THE TIDILI

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Providing drinking water to many small communities triggered a dramatic increase in wastewater production, bringing out the necessity for collecting and treating wastewater in these communities. Wastewater collection and treatment are problematic in these areas due to mountainous terrain and dispersed population. Ecological technologies such as constructed wetlands for wastewater treatment represent innovative and emerging solutions for environmental protection and restoration, placing them in the overall context of the need for low-cost and sustainable wastewater treatment systems in small communities.

The aim of this study was to evaluate the purifying efficiency of a combined subsurface vertical and horizontal flow constructed wetlands system for the treatment of domestic wastewater in rural area. The experiment was set up in small rural community named Tidili located in the region of Marrakech. The wastewater treatment plant was composed of three vertical-subsurface flow wetlands (VF), working in parallel. Thereafter, followed by two horizontal-subsurface flow wetland (HF) connected also in parallel. The two units were planted with *Phragmites australis* at a density of 4plants/m². Several water quality parameters including pH, BOD₅, COD, TSS, TKN, TP and fecal bacteria's number in both raw and treated wastewaters were monitored during two years. Wastewater samples were collected fortnightly at the inlet of the storage tank (after the lift station) and at the outlet of both the VF and HF stages from April 2014 to February 2016.

The main removal percentages of TSS, BOD₅, COD, TN and TP were respectively 95, 93, 91, 67 and 62%. In addition, the Log10 removal for total coliforms, fecal coliforms and fecal streptococci were 4.46, 4.31 and 4.10 Log unit respectively. Based on the obtained results, the hybrid constructed wetland technology is a successful method for rural region and provides good purification performance in terms of removal of organic matter, nutrients and indicator bacteria of fecal contamination. Thus, it can be concluded that hybrid constructed wetlands could be considered as a low cost technology adapted to Moroccan rural areas for domestic wastewater treatment.

KEYWORDS: hybrid constructed wetland; *Phragmites australis*; mountain area; domestic wastewater.

Acknowledgement : The authors would like to thank the National Centre for Research and Study on Water and Energy (CNEREE), Cadi Ayyad University; the Laboratory of Hydrobiology, Ecotoxicology and Sanitation (LHEA, URAC 33), Cadi Ayyad University; and the Pole of Competences on Water and Environment (PC2E) for their technical support of this research.

EXPERIMENTAL ANALYSIS AND PROCESS OF WASTEWATER TREATMENT PLANT

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INTRODUCTION

Wastewater treatment plants play an important role within the urbanwater cycle and they are considered an industrial activity where wastewater is transformed by means of different processes, which consume chemicals and energy, into treated water (of higher quality), generating byproducts (primarily solid wastes and gaseous emissions) [1]. An efficient waste treatment strategy should be cost-effective and minimize potential impacts on various stakeholders and the environment [2]. It is a result of prudent and scientifically justifiable decision-making that minimizes the risks to the environment and human health, and maximizes cost efficiency. A sustainable waste management is also achieved. In this research a process analysis of wastewater treatment plant is carried out to find the optimal operating conditions through energetic optimization of distillation column.

MAIN RESULTS

The wastewater treatment plant processes hazardous liquid waste and not. It has two interconnected lines: biological treatment (for non-hazardous waste) and chemical treatment (for hazardous waste). Figure 1 shows the schema of the process: the pretreatment, multiple effect evaporation, concentration and drying, distillation section are present. The distillation section is characterized by excessive and diluted feed comprising the evaporated from the multiple effect, drying and concentration section. This involves high consumptions of steam, cooling water and disposal costs of distillate. The feed flow-rate is equal to 3500 kg/h (with 80% w/w of water): organic and chlorinated solvent are mainly separated. The temperature of packed column is equal to 64 °C, the pressure is atmospheric with 25 theoretical stages. To overcome this problem two alternative solutions are considered: a-only current from vessel D201 is sent to distillation; b-current from vessel D201 and evaporated of first effect of multiple effect are sent to distillation. All other evaporated currents of the plant are sent to biological treatment. In vessel D201 the soluble solvents separated by reboiler at inlet of the plant are present. In this way the feed of distillation is more concentrated (around 50% w/w of water) and with lower flow-rate (1900 kg/h respecting the condition of minimum wettability). This helps the separation, increasing the production of distillate and reducing the production of residue. An energetic and economic analysis of the process is carried out to establish the better solution using a simulation process ChemCad 6.3[®]. The costs of distillation (cost of steam, distillate disposal

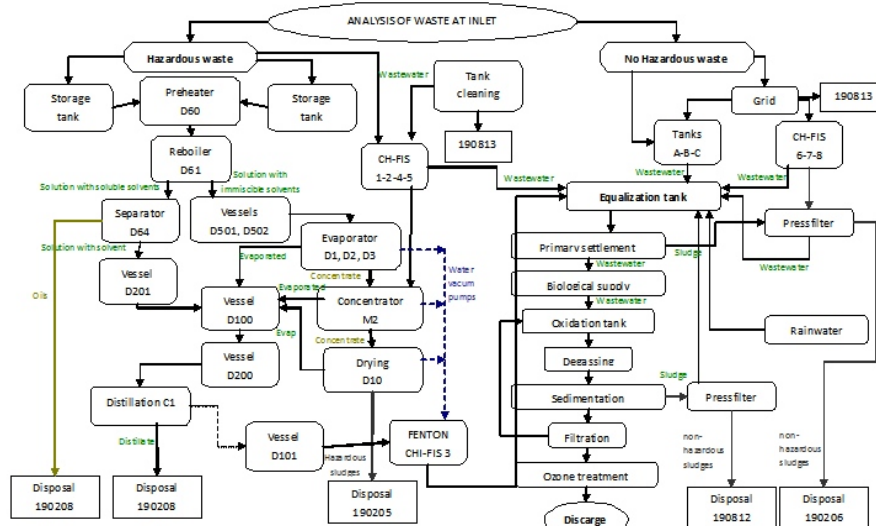


Figure 1: Schema of wastewater treatment plant

and cooling water) and evaporation section (cost of cooling water) are considered. Results show that sending only current from vessel D201 to distillation it is possible to have an higher economical saving respect to traditional schema. In particular a and b solution allow to have 66% and 57% of economical saving respectively. The traditional plant costs 573.000 euro/year, solution b 244.700 euro/year, solution a 196.500 euro/year. In addition the value of COD in the bottom of column are lower in the better solution: 894 kg/day of COD are send to biological treatment (Fenton reactor) against to 2586 kg/day of current operating. The temperature of 110 °C and 3%w/w of solvents in residue are respected. Also the temperature of 60 °C and 5%w/w of water in distillate are respected. The influence of COD value to biological section obtained by this vessel solution will be the subject of future studies. A study of the process according the factorial design is also involved. The factors are: feed temperature, reflux ratio, steam flow-rate, number of stage. The responses are: distillate purity, percentage of solvents and COD at bottom of column, residue flow-rate. Results show that feed temperature has negative effect on COD, residue flow rate and solvent of residue but has a positive effect on water in distillate. The steam flow rate has a negative effect on COD and solvent of residue while reflux ratio has a negative effect on water of distillate and positive effect on residue flow rate. The number of stage is important only with high amounts of solvents in feed.

Acknowledgement

The author would like to thank G.S.A. S.r.l. for the plant

References

- [1] D. Godin, et al., Water Sci. Technol. 2012. pp. 1624-1631, Net environmental benefit: introducing a new LCA approach on wastewater treatment systems.
- [2] Atousa Soltani, et al., Journal of Cleaner Production, vol. 113, 2016, pp. 388-399, Selecting sustainable waste-to-energy technologies for municipal solid waste treatment: a game theory approach for group decision-making.

TESTING PROTOCOL FOR ASSESSMENT OF TECHNOLOGIES FOR GREYWATER TREATMENT

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Water stress, whether due to climate change, population growth or high pressure on the resource, is an increasing issue. Most countries are facing it or will face it soon and they have to adapt their water management plans accordingly. In France, water conservation at the building scale is currently an important concern. Greywater reuse is a solution that is gaining acceptability. It is seen as an available back-up for a scarce fresh water supply or as a way to alleviate pressure on wastewater disposal systems. At a domestic scale, 60% to 70% of the water demand is converted into greywater, which refers to all domestic wastewater excluding the input from toilets. Greywater is considered a reliable source of water with an average daily production ranging between 60 and 180 L per person living in developed countries. The reuse of this resource to flush toilets could help save between 20% and 47% of the average domestic water consumption. Diversity in treatment technologies is accompanied by diversity in the ways countries perceive and manage greywater treatment and reuse, and no common international regulations on the quality standards recycled greywater should meet could be identified.

The objective of the present study was to expand understanding of greywater treatment and reuse to contribute to a safe integration of this practice. In a first phase, the international guidelines were reviewed to identify the current standards that recycled greywater should meet and suggest a testing protocol for assessment of treatment performances. In a second phase, a commercially available greywater treatment system was operated to evaluate the quality of the treated greywater it produced under various conditions, and assess its compliance against chosen references.

Based on literature review, countries which already produced guidelines were identified. The documents could be sorted into two categories: the guidelines on general wastewater reuse and the ones that focused on greywater. To date, there is no common international or European regulation on greywater treatment and reuse. In some countries, wastewater reuse for different intended end-uses, such as irrigation or toilet-flushing, is already accepted and experienced, and some guidelines were established. They target different scales of treatment, and depending on this scale, they are addressed to users, to help them choose a safe system and operate and maintain it properly, to manufacturers who are looking for an accreditation of their treatment technologies, or to the authorities, when it is their responsibility to control the systems that their citizens are using.

The study revealed the importance of setting relevant quality standards, which determine the required levels of technology, and the need for a testing protocol to assess the performances in real conditions including simulations of various failures to be able to avoid or mitigate them to prevent health risks.

Lab experiments on a commercially available treatment unit highlighted the important aspects that a testing protocol should cover. The key points for the drafting of a guideline appeared to be:

- The choice of monitored parameters that should give a representative idea of the greywater quality: organics, solids and micro-organisms.

- The setting of quality standards that should prevent health risks for the users, keeping in mind the required level of technology they will imply.
- The writing of a testing protocol that would place the systems in operating conditions and simulate failures and variations in their environments.

KEYWORDS: Greywater reuse; Guidelines; Treatment performances; Health risks; Testing protocol

MULTI-SOIL-LAYERING (MSL) SYSTEM: NOVEL TECHNOLOGY FOR EFFICIENT TREATMENT OF DECENTRALIZED DOMESTIC WASTEWATER IN MOROCCO

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Providing drinking water to many rural areas of Morocco has increased a dramatically wastewater production. In these regions, there are a large number of communities and villages where small populations lack wastewater infrastructure, which have insufficient financial resources, poor maintenance and lack of properly trained staff to operate classical technologies. Therefore, wastewater was usually poorly collected and directly discharged in the environment causing a significant environmental and health risk. In recent years, a novel technology of wastewater treatment called multi-soil-layering (MSL) system has been introduced and successfully tested for secondary wastewater treatment in Japan, Thailand, USA, China and Taiwan. The investment and operational costs of MSL method were very low compared with lagoons and wetlands. The application of high hydraulic loading rate and the effective life was estimated to be longer than 20 years for domestic wastewater treatment [1]. MSL system could be an adequate option to treat domestic wastewater for small communities in rural areas of Morocco. Recently, MSL system was tested in laboratory scale in Morocco using local materials and the results were very encouraging [2]. The main objective of this study is to evaluate the efficiencies of MSL systems for treating rural domestic wastewater characterized by high concentrations of organic matter and nutrients. The effect of applied hydraulic loading rate (HLR) on MSL pilot's performances has been also examined.

The experiment was carried out in Talat Merghen village (South of Marrakech city, Morocco). Domestic wastewater from eight lived houses (72 inhabitants) was collected by a settling tank with a volume of 1 m³ and used to feed the MSL pilots plant. The experimental setup included three similar MSL systems operated during one year. MSL systems were composed of soil mixture layers (SML) and gravel permeable layers (PL) that are arranged in a brick-layer like pattern. The SML comprised local sandy soil, charcoal, sawdust and iron on a dry weight ratio of 70, 10, 10 and 10 %. The applied HLR were 1000, 2000 and 4000 L.m⁻².day⁻¹.

The obtained results showed average reduction efficiency of 77-87, 57-79, 51-76, 56-67 and 47-66 % for TSS, BOD₅, COD, TN and TP respectively. The mean removal percentage of SS, BOD₅, COD and TP was higher at lower HLRs, whereas TN was not significantly influenced by the HLR changes. In terms of absolute loading rate, a satisfactory removal rate pattern was achieved. The MSL system purification efficiency ranges between 278-1596 g SS m⁻².day⁻¹, 447-2157 g BOD₅ m⁻².day⁻¹, 613-2824 g COD m⁻².day⁻¹, 73-293 g TN m⁻².day⁻¹ and 8-33 g TP m⁻².day⁻¹.

Therefore, MSL technology could be considered as a promising wastewater treatment alternative for rural domestic wastewater characterized by high concentration of organic

matter and nutrients under arid climate of Morocco. The low hydraulic loading rate is recommended for efficient removal percentage of suspended solid, organic matter and phosphorus. In terms of absolute loading rate, high quantity of all pollutants removal was shown by the higher HLR applied to the MSL pilot plant.

KEYWORDS: Wastewater treatment; Multi Soil Layering system; hydraulic loading rate; organic matter; nutrients.

Acknowledgement

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References

- [1] Chen, X., Luo, A.C., Sato, K., Wakatsuki, T., Masunaga, T., 2008. An introduction of a multi-soil-layering system: a novel green technology for wastewater treatment in rural areas. *Water Environ. J.* 4, 255-262.
- [2] Latrach, L., Masunaga, T., Ouazzani, N., Hejjaj, A., Mahi, M., Mandi, L., 2015. Removal of bacterial indicators and pathogens from domestic wastewater by the multi-soil-layering (MSL) system. *Soil Sci. Plant Nutr.* 61 (2), 337-346.

INTEGRATED APPROACH FOR DECENTRALIZED WASTEWATER MANAGEMENT IN JORDAN: ENCOMPASSING SOCIAL, TECHNICAL AND ECONOMICAL ASPECTS

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This paper aims at documenting the experience of Royal Scientific Society (RSS) in the decentralized wastewater management in rural and peri-urban areas in Jordan. Royal Scientific Society was involved in the project of “expanding access to sanitation for unsewered communities in Middle East and North Africa countries” which primarily aimed at assessing the technical, social, environment and financial opportunities and challenges facing decentralized wastewater management in Jordan; and developing innovative and low cost sustainable wastewater treatment systems through experimentation, and promotion. The project started in February 2014 for two years and was funded by the Middle East and North Africa Network of Water Centers of Excellence MENA NWC/USAID. The project was implemented in *Sakeb* village at Jerash governorate, where the most practiced wastewater collection method is the use of pit latrines and unlined cesspools that causing detrimental impacts on human and surrounding environment. The work and methodology insured close consultation and active participation of the communities to determine the feasibility of adopting innovative, nonconventional wastewater management policies for small unsewered communities in Jordan. For this purpose, a coherent framework of activities including integration of various components of social, technical, economical, environmental, institutional and public participation requirements was set and implemented.

The project started with involvement of local community members by establishing a partnership with one active women community-based organization (CBO). The project team, in close consultation, with the selected CBO formulated the local stakeholder committee so as to voice the need of local people regarding water and wastewater and to work hand-in-hand in addressing the opportunities and challenges that are associated to decentralized wastewater treatment. The local stakeholder committee comprised of representatives from the community leaders, local people, women, non- governmental organization NGOs, CBOs and governmental officers. A literature survey was conducted to better understanding of the issues related to the appropriate treatment technologies that are already tested and practiced in small communities of similar conditions. A technology selection matrix was developed taking into account all technical and socio-economic aspects as well as the local environmental conditions. Relative Importance Indices (RI) analysis was used to rank the technologies as per the criteria given. Accordingly, the modified septic tank (MdST) and the recirculating constructed wetland (RCWT) were selected to be piloted in *Sakeb* village.

Two clusters of households in *Sakeb* village were selected to construct and operate the pilot treatment units. The first cluster comprised of 5 dwellings with 38 inhabitants and the second one has 4 dwellings with 25 inhabitants. The average wastewater quantities generated ranged from 36-42 liter/capita/day. The generated wastewater seemed to be strong in terms of organics contents, where BOD₅ ranged from 1000 to 1200 mg/l, and COD ranged from 2100 to 2375 mg/l. In order to design, construct and operate the two small-scale wastewater treatment plants in the targeted areas, the project team, in collaboration with the local community, developed all engineering design and drawings, in addition to all necessary tender documents as per the local regulations. After 6 months of monitoring, the laboratory

results showed that the efficiency of the modified septic tank in terms of BOD₅ and TSS reached up to 80% and 65%, respectively. However, Nitrogen removal, represented by TKN and NH₃ did not exceed 10%, implying the need to enhance the nitrification process. The recirculating constructed wetland demonstrates high removal efficiency with about 90% removal in BOD₅, 85% removal in TKN and NH₃ and 95% in TSS. In order to improve the removal efficiency of the *E.coli*, the project team developed the concept of using eco-friendly synthesized nanoparticles in decentralized wastewater treatment, where a galvanized cylinder was designed and placed at the discharge point of the modified septic tank and filled with Nano-particles. The Nano-filter unit was able to remove 2-3 logs of *E-coli* content in the modified septic tank effluent. However, further investigation is required to fully optimize the nano-filter as a disinfection unit in wastewater treatment plants. Nevertheless, the treated water met the Jordanian Standards for restricted irrigation and is being used for olive and other fruit trees production.

The social economic survey and the level of users' satisfaction suggested that the recirculating constructed wetland was more reliable and user-friendly when comparing to the modified septic tank. The project resulted in developing guidelines for wastewater management on household level in the small communities in Jordan, increasing public awareness and community participation in fields of wastewater management and reuse and publishing the operation and maintenance manual to provide the community with the know-how on decentralized wastewater treatment and reuse issues.

KEYWORDS: decentralized wastewater treatment, public participation, selection matrix, recirculating constructed wetland, modified septic tank.

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AN INSIGHT IN WATER DECONTAMINATION BY PHOTOCATALYSIS OF $ZnFe_2O_4$ ELABORATED BY SOL-GEL PROCESS

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Complex issues relating to water have become strategic and sensitive. Sources of pollution threatening the quality of water, so precious to public health, are becoming more numerous and diverse. The heterogeneous photocatalysis is emerging as a promising new technology for the reduction of organic and inorganic pollutants in the water. This method consists of activating the catalytic properties of a photosensitive material through solar radiation.

In this study, we are interested in the study of zinc ferrite ($ZnFe_2O_4$), obtained by sol-gel method. First, we will demonstrate the versatility of the sol-gel process that achieves both homogeneous powders with controlled particle size and thin films with an adjustable thickness. The effect of heat treatment temperature and thickness were investigated by *studying the photocatalytic activity* on an industrial dye (orange G).

KEYWORDS: Photocatalysis, thin films, ferrites, water decontamination, Sol-gel

MODIFIED ZNO NANOPARTICLES THIN FILMS AS VISIBLE LIGHT PHOTOCATALYSTS FOR WASTEWATER TREATMENT

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Silver (Ag) and zinc oxide (ZnO) nanoparticles were simultaneously deposited on a glass substrate using the radio frequency (RF) sputtering technique at different substrate temperatures. Detailed characterization of the co-sputtered Ag/ZnO thin films were performed by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM) and X-ray photoelectron spectroscopy (XPS). The as synthesized thin films were tested with UV-Vis diffuse reflectance spectroscopy to evaluate their optical properties. These nanoparticles have average particle size of 20 nm. The optical band gap value had been calculated from UV transmission spectra of Ag/ZnO thin films deposited at various substrate temperatures. This value was observed to be in the visible light range (i.e. 2.7-3.1 eV), which is much smaller than that of pure ZnO (3.37eV). The photocatalytic activity of the produced thin films was evaluated through visible light photo degradation of 2-chlorophenol (2-CP) which, has been used as a pollutant model in water. The synthesized thin films showed enhanced visible light photocatalytic efficiency towards 2-CP degradation at elevated substrate temperature and retained its catalytic efficiency with only 8% loss in efficiency after four reuse cycles. Kinetic parameters involved in the degradation process were investigated by applying pseudo-second-order kinetic model.

Key Words:

Nano thin films, RF-sputtering, visible light, photodegradation, pollutants, wastewater

STRUCTURE INFLUENCE OF PbO_2 FILMS ON WATER DEPOLLUTION: ADHESION, KINETICS AND OXIDATION CAPABILITY

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INTRODUCTION

Electrochemical oxidation is in widespread use for elimination of pollutants from industrial wastewater. Recently, many studies have focused on ways to improve the electrochemical activity and stability of the electrode materials, in order to enhance the removal efficiency of synthetic dye [1, 2]. The purpose of this work is the investigation of the effect of cyclic voltammetry (CV) on electrochemical behavior of PbO_2 layer electrodeposited by pulsed (PC) and galvanostatic (G) method on stainless steel (SS) and the effect of SiO_x as an interlayer between stainless steel and lead oxide as well as a solution to improve adhesion of oxide layer to stainless steel substrate by their forms crystallites, and this may have a deleterious effect on the electrochemical degradation activity of this film.

MAIN RESULTS

It is reported in this work that the PbO_2 films electro-deposited by galvanostatic (G) and pulsed current (PC) methods on stainless steel (SS) were used as anodes for treating Amaranth dye. The PbO_2 films on stainless steel were proved to be good activity, relatively low cost and high stability, when modified their properties. The first solution is to modify their structures and morphology by cyclic voltammetry (CV). The second one required to deposit the SiO_x as an interlayer formed by plasma-enhanced chemical vapor deposition (PECVD) which was used in plasma-fused with tetraethoxysilane (TEOS), O_2 and Ar in different ratios. Obtained layers were examined by different techniques. Such as SEM, Field emission scanning electron microscope (FESEM). PbO_2 composition formed on different anodic layers was examined using X-Ray diffraction (XRD). Electrochemical behavior of the prepared samples was investigated by different electrochemical measurements, Electrochemical Impedance Spectroscopy (EIS) and cyclic voltammetry (CV).

EIS results revealed that the charge transfer resistance significantly decreased because the lead sulfate layer is more compact and the access of electrolyte ions to the internal layer is blocked and the difference in ratios of $\beta\text{-PbO}_2$ and $\alpha\text{-PbO}_2$ at lead oxide explaining the observed difference in CPE_{dl} and R_{ct} . Experimental results using synthetic water polluted by azo dye demonstrated higher color and COD removals at acidic pH which reached after 300 min, 95% color removal and 80% COD removal for SS/ SiO_x (20:20:1)/ PbO_2 (PC), compared to 100% and 84%, respectively, using SS/ SiO_x (20:20:1)/ PbO_2 (G).

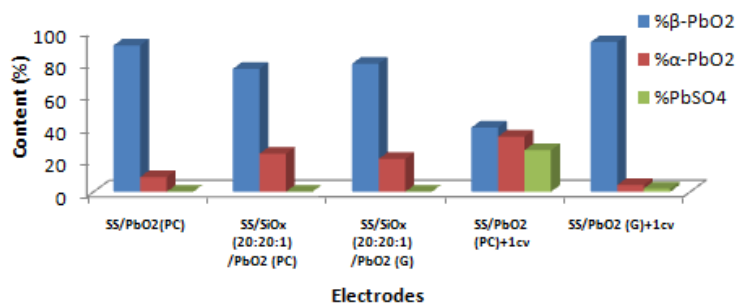


Figure 1: α -PbO₂, β -PbO₂ and PbSO₄ crystallites compositions for lead oxide layers deposited on different used anodes.

The color and the COD removals on electrode PbO₂ (G) with one cyclic number of CV achieved nearly to 100% and 85%, respectively, comparing to 97% and 83% using PbO₂ (PC) electrode.

Composition of oxide lead layers are investigated by X-Ray diffraction (XRD) and obtained results demonstrated that when SiO_x interlayer has a higher oxygen amount, the nucleation of β -PbO₂ crystallites is faster.

The ratio of PbSO₄ increases throughout the cyclic number of CV applied. It is related to reduction phenomena depending on electron transfer through the pores into β -PbO₂ layer.

As a conclusion, the ratio of β -PbO₂ played important role in the performance on dye degradation because β -form presenting more porous structure can acts on the semi conductor proprieties with the possibility of more ability for electron moving.

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References

- [3] Lazhar Labiadh et al., Journal of Electroanalytical Chemistry, vol. 766, 2016, pp. 94–99
- [4] Carlos Alberto Martinez-Huitle et al., Environmental Science and Technology, vol. 42, 2008, pp. 6929–6935

COMBINING MICELLE-CLAY SORPTION TO SOLAR PHOTO-FENTON FOR WASTEWATER TREATMENT

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Introduction

There is an increasing interest in reusing treated wastewater (TWW) in water-stressed countries and those suffering from water scarcity. Up to now, secondary domestic TWW (from which degradable organic matter and suspended solids have been removed) can become reclaimed water for non potable purposes mainly by adding a filtration step (e.g., slow sand filtration) and an enhanced disinfection step (chlorination or UV radiation). Unfortunately, these processes sometimes fail to meet wastewater reuse standards, particularly in terms of bacterial inactivation, show decreases in performances when organic matter content increases and are ineffective for emerging contaminants (ECs) removal. Treatment technologies with low energy requirements and that can be easily integrated in existing purification systems probably represent the future of wastewater treatment in order to ensure sustainable reclaimed water reuse. Advanced oxidation processes (AOPs) are good options because these technologies result in an overall water disinfection together with removal of ECs and can be operated under solar light.

Main results

This work reports a tertiary treatment of biological domestic waste water treatment plant effluent using a filtration step with nano-composites of micelle-clay mixed with sand (20:100, w/w) combined with solar photo-Fenton oxidation step using persulfate as oxidant. This combination of simple, robust and low cost technologies aims to ensure water disinfection and emerging contaminants (ECs, mainly pharmaceuticals) removal. None of these two technologies taken separately was able to comply with this aim. The filtration step showed good performances in removing dissolved organic matter which otherwise produced toxic disinfection by-products upon oxidation and *cryptosporidium parvum* cysts, being quite resistant to oxidation. In contrast, photo-Fenton allowed for elimination of a large set of ECs, reducing estrogenic activity of effluent and ensure disinfection with respect to fecal indicators. More precisely, the filtration unit allowed for 4 log abatement in E.coli and fecal Enterococci in compliance with the French regulation on wastewater reuse for irrigation and allowed for the reduction of TOC values from 26 to 1 mg/L. This result is in contrast to GAC filtration which was hardly able to reduce the wastewater bacteria content. When dealing with the sorption step, the removal of targeted ECs was limited with the exception of two anionic pharmaceutical substances (diclofenac and mefenamic acid) with removal rates nearly reaching 100%. However, the photo-Fenton oxidation achieved to eliminate all investigated compounds after 120 min solar irradiation. Human cell-based bioassays were sensitive enough to control genotoxic and estrogenic activities in domestic WWTPs effluents, showing that the solar photo-Fenton treatment significantly reduced the estrogenic activity and genotoxicity of domestic effluents. The current major limitation of the proposed technology is the low water volume able to be handled (a few m³/day), making this technology suitable for wastewater treatment in small communities or small craft companies.

Conclusions

Combining a filtration step involving micelle-clays and solar photo-Fenton have shown promising results for domestic WWTPs effluent treatment.

Keywords: Micelle-clay; solar photo-Fenton; emerging contaminants; disinfection.

THE OPUNTIA FICUS INDICA JUICE AN ECO-FRIENDLY ALTERNATIVE TO CHEMICAL COAGULANTS AND FLOCCULANTS USED IN PHYSICOCHEMICAL TREATMENT OF INDUSTRIAL WASTE AND SURFACE TREATMENT OF TEXTILE

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The *Opuntia ficus indica* is a tree native to the arid and semi-arid areas of Mexico. It belongs to the genus *Opuntia*, it is a succulent xerophytic plant capable of storing a large amount of water and has no the danger to human health. It also has a considerable values in cosmetic, medicinal and food areas.

Furthermore, this study consist on the use of a new natural biodegradable flocculant Based on Moroccan *Opuntia ficus indica* juice in a physical-chemical process (coagulation-flocculation) for treating liquid waste laden textile dye and heavy metal.

Coagulation-Flocculation is a physico-chemical treatment method for purification of water, used for treatment of drinking water or waste water treatment. The coagulation consist on the elimination of inter colloidal repulsion and the flocculation resolve the problem of the small diameter of the colloids. The real concern is in fact the mass, which does not allow natural sedimentation and exploitable under treatment. Adding flocculant induces aggregation of colloidal particles. Subsequently, this agglomerate of colloids called floc has sufficient mass to be able to settle.

Industrial effluents have a high load of carbon pollution and dyes that require treatment before discharge into the receiving environment. In this study, we focused on *Opuntia ficus indica* juice valorisation as a natural substance used in such treatment. The coagulation-flocculation method was chosen for introducing the *Opuntia ficus indica* juice as a biodegradable flocculant (bio-flocculant). Processing is carried out in two main stages. The first stage is the pH adjustment with lime and / or sulfuric acid and then the flocculation with the *Opuntia ficus indica* juice. The parameters that were studied in this work are pH, Turbidity, COD, absorbency of dyes in textile effluents, metal content and conductivity.

To goals were achieved, first a water concentration of metals that respect the regulation for discharge in surface water treatment discharges, and secondly, a removal rate of dyes that can reach 88%, 97% percentage of turbidity abatement and an COD removal in the order of 66% for textile releases.

The treatment with *Opuntia ficus indica* juice (prickly pear) has a lot of advantages: this process will be a good opportunity for local economic development, and we will see the changes on physicochemical properties of the treated sample and mud recovered will be biodegradable and free of iron or aluminum and chemical polymers, another advantage is that *Opuntia ficus indica* juice has no polymerization and synthesis complexity as synthetic flocculants. It can be a very good alternative to chemical coagulants and flocculants widely applied in the water treatment field and having drawbacks on the environment and in particular on human health.

An effort of research and development is necessary, therefore, to unveil the secrets of this miracle plant.

KEYWORDS: bio-flocculant, *Opuntia ficus indica*, coagulation-flocculation, effluent discharges, Textile processing, heavy metals, surface treatment.

SYNTHESIS AND CHARACTERIZATION OF CHITOSAN- STEVENSITE NANOCOMPOSITE: APPLICATION IN REMOVING HEAVY METALS FROM AQUEOUS MEDIA

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Many different anthropogenic activities can contaminate water sources, leading to serious environmental concerns. The discharge of heavy metals into the environment has become a matter of concern over the last few decades. Heavy metals such as lead, mercury, zinc, cadmium, Copper and cobalt have been the common existent pollutants in the environment from various natural and industrial sources. Clay minerals have great potential as inexpensive and efficient adsorbents due to their large quantities, chemical and mechanical stability, high surface area and structural properties. A specific clay mineral is under study in this work, namely: Moroccan stevensite. This clay mineral is the major constituent of the locally called "Rhassoul" clay. The only known natural *deposit of Rhassoul* is located in a small mountain at the east side of the Middle Atlas Mountains of Morocco.

The main objective of this work was the synthesis of bionanocomposites based on swelling clays and polymers. The improved adsorption properties were tested by studying the retention of cationic pollutants. A polymer studied in this work, namely chitosan, is obtained by deacetylation of chitin, one of the most available natural polymers on the earth. This polymer is an excellent natural adsorbent in that its amine (NH_2) and hydroxyl (OH) groups may serve as coordination sites to form complexes with various heavy metal ions. It can remove metal ions effectively by adsorptive enrichment. After purification and extraction, the stevensite clay mineral was modified by intercalation of commercial chitosan. The increase of the interlayers distance of clay mineral was confirmed by X-ray Diffraction. The d_{001} reflection was shifted from 15 \AA to 17.8 \AA . The bionanocomposite was also characterized by Fourier Transform Infrared Spectroscopy (FTIR) and Thermal Analysis (TGA / DTA), with an important weight loss between at $200 \text{ }^\circ\text{C}$ and 400°C . This indicates that about 11% of chitosan was successfully coated onto stevensite. It was concluded that the nanocomposite material of chitosan and stevensite was successfully synthesized.

The nanocomposite Stevensite-chitosan was used to remove metal cations from aqueous solution. Different adsorption isotherms on stevensite and stevensite modified by chitosan were determined for mercury Hg (II), zinc Zn (II), cobalt Co(II), Cadmium Cd(II), lead Pb(II) and copper Cu(II). These isotherms were then modeled by using two empirical approaches: Freundlich and Langmuir models. The study of the capacity of heavy metals elimination from aqueous solution by natural stevensite and stevensite intercalated by chitosan shows that an improvement of heavy metals adsorption on nanocomposite chitosan-stevensite is obtained. The presence of chitosan is particularly *important* for the *complexation of heavy metals*

The adsorption complexes obtained were also characterized by X-Ray Diffraction (XRD), Thermal Analysis (TGA / DTA), X Ray Fluorescence (FX), Transmission electron microscopy (TEM) and Fourier transform infrared spectroscopy (FTIR).

Keywords: Stevensite, Chitosan, Bionanocomposite, Characterization, Adsorption, Heavy Metals

EGGSHELL ADSORPTION PROCESS COUPLED WITH ELECTROCOAGULATION FOR IMPROVEMENT OF CHROMIUM REMOVAL FROM TANNING WASTEWATER

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The manufacture of leather has been an important activity since antiquity; it is a transformation process of animal hides into leather involving various chemical and mechanical operations to clean the skin of meat, fat and hair. Chromium tanning process is one of the most common methods for processing hides. There are more than 60 tanneries in Morocco of which the majority adopt this process, mainly because of the good quality of leather obtained. However these tanning processes pose a threat to the environment because they carry a variety of organic and inorganic chemicals reflected by high values of chemical oxygen demand (COD) and chromium III discharged into receptor media. Chemical oxidations of Cr(III) to Cr(VI) as a consequence of oxidation or natural bio-transformations in the environment, is a source of possible mutagenic and carcinogenic hazards.

Although new tanneries use modern equipments with optimal adjustment of the chromium quantity, conventional chromium bath tanning processes still use chromium salts in excess. The leather takes up only 60 to 80% of the introduced chromium. Depending on the efficiency of the operation, wastewater contains chromium species, which must be removed before disposal.

Our previous studies on electrocoagulation process provides a simple, reliable, and cost-effective method for the treatment of tannery wastewater concentrated of chromium without the need for additional chemicals, and thus, without the production of secondary pollution. Also the adsorption using natural adsorbents is proved to be very effective techniques for removal chromium from tannery waste water.

The present work deals with removal of trivalent chromium from chrome tanning effluent in a batch stirred electrocoagulation cell with aluminium alloy coupled with adsorption using Eggshell (ES). Effects of operating time, current density and adsorbent dose have been investigated. Compared to simple electrocoagulation (EC), the concentration of chromium using EC/ES coupled have been successfully reduced to environmentally acceptable levels even with a concentrated effluent (3.21g/L). The maximum uptake of chromium ions was obtained at lower current densities 200A/m², at operating time 110 min and with the dose 12g/L. The energy consumption during electrocoagulation and coupled adsorption was also reduced about 60% comparatively to simple electrocoagulation. Kinetic data were satisfactorily described by a pseudo-second order chemical sorption model. The water treated

by these technique, respects the strengths Moroccan standards and the method was found to be highly efficient and relatively fast compared to existing conventional techniques.

Keywords: Chromium tanning, Electro-coagulation /adsorption, Aluminum alloy, Eggshell, Energy consumption.

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COMPARISON OF OLIVE MILL WASTEWATER TREATMENT BY MEMBRANE BIOREACTOR AND CONVENTIONAL ACTIVATED SLUDGE

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Activated sludge (AS) is the most commonly used process in wastewater treatment plants all over the world. Nevertheless, the strong industrial effluents which are highly concentrated and complex penalize the settling step in terms of efficiency, membrane bioreactor (MBR) has appeared recently as a novel process that presents very high depuration efficiency and is currently challenging AS.

Several studies aimed to compare performances of MBR and AS in treatment of both municipal or industrial effluents from different origins. However, at the best of our knowledge, study comparing MBR and AS in the case of olive mill wastewater (OMWW) has not been reported. The purpose of the work presented here is to investigate and compare the performances obtained during the operation of two pilots: MBR and AS for the treatment of OMWW.

The experiment was carried out separately in two treatment pilot plants: AS and MBR and investigate the treatment performances of both systems under optimal and stable conditions fixed over a period of 20 days. AS and MBR Pilots alimented with OMWW was made under variable influent flow and F/M ratio of about $0.3 \text{ kgCOD} \cdot \text{KgMLSS}^{-1} \cdot \text{j}^{-1}$ for AS and $0.2 \text{ kgCOD} \cdot \text{KgMLSS}^{-1} \cdot \text{j}^{-1}$ for MBR. For comparing the systems performances, the main parameters monitored were COD, phenolic compounds and suspended solids (TSS) removals, turbidity and sludge production.

The results obtained showed a better elimination of carbon pollution (95%) in the case of MBR than for the CAS system (86%). For phenolic compounds removal, both systems succeeded to eliminate these compounds in the same range of (80%). Hydrotyrosol and tyrosol are the main compounds removed from OMWW influent treated both in CAS and MBR. Concerning the sludge production, the AS produced high quantity of sludge even if this system has operated at too high sludge retention time (SRT) than for MBR.

In the other hand, the MBR came to produce an effluent of higher quality with suspended solids (TSS concentration equal to $1 \text{ mg} \cdot \text{L}^{-1}$ and a final turbidity of 2.12 NTU, while the AS system outlet achieved an elimination of the TSS of about 25 to 30 $\text{mg} \cdot \text{L}^{-1}$ and 5 to 7 NTU for final turbidity.

In conclusion, MBR seems to have higher potential for OMWW treatment than conventional activated sludge.

KEYWORDS: Olive mill wastewater; Conventional activated sludge; Membrane bioreactor; Removal efficiency; settleability and filtration performances

Acknowledgement: This work was supported by the Moroccan-French cooperation project devoted to restructured pole of competences on Water and Environment (PC2E).

ASSESSING THE CHEMICAL/MICROBIOLOGICAL CONTAMINATION AND PRODUCTIVITY IN THE AGRICULTURAL PRODUCTION CHAIN OF MODEL FRUIT SPECIES GROWN UNDER IRRIGATION WITH DIFFERENT KINDS OF RECLAIMED WASTEWATER: PRESENTATION OF THE “IRRIGATIO” PROJECT

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Limited fresh water (FW) availability is a problem of increasing concern in the world as FW resources are becoming insufficient to efficiently sustain agricultural irrigation, mainly due to climate-related conditions. It should be noted that a relationship between available water resources and the ability to produce food exists and that a strong correlation between the volume of FW available in a certain country and the quantity of food imported by that country has been highlighted.

Actions aiming at increasing water availability for agriculture in arid and semi-arid areas should be therefore encouraged, as tools of overcoming this important natural constraint to the country's economic growth. Accordingly, over the past few decades, a growing attention has been devoted to the search of alternative sources of water for agriculture, also in view of replacing other high-quality water, suitable for human consumption. The reuse of municipal or mixed municipal/industrial wastewater for irrigation could be an efficient tool of reducing water shortage, even though the plant growth and productivity could be negatively affected and a number of concerns regarding human and environmental health aspects should be taken into account. Even though North African and Middle East regions suffer of FW shortage, limited availability of FW resources is an actual problem also in countries traditionally considered rich in water, like, for example, Italy, especially in the southern part. Moreover, an increasing attention is devoted to limiting the impact of treated water (TW) on the overall quality of receiving freshwaters in European countries, also as a consequence of the strict environmental quality standards indicated by European regulations. In this regard the European Commission announced the ERANETMED call for research proposals on Renewable Energies, Water Resources and their connections for the Mediterranean Region, under which the “IRRIGATIO” Project was selected and financed. This project involves the participation of all partners herein listed as authors and deals with the reuse of TW for irrigation purposes of selected crops, chosen according to the “project idea” of investigating plant species characterized by different vulnerability to chemical and microbiological contamination. Different TWs from urban, mixed urban-agro industrial and mixed urban-textile origins will be

tested, according to the specificity of the Countries involved in this project. Wastewater will be treated according to different treatment trains, using activated sludge, clariflocculation, membrane biological reactors, constructed wetland and ozonation stages. The TWs will be used for the irrigation of model plants in field-scale and/or mesocosms and/or in pots, with cultivations irrigated with FW as controls. The plants (e.g. olive and strawberry) were chosen considering their economic value in the Countries involved in the project and in order to share at least one common species between at least two partners, thus allowing for the comparison of the reuse impact of different TWs on the same species. Plants will be evaluated for their growth, development and crop production. Chemical and microbiological contamination indicators will be monitored along the whole agricultural production chain (i.e. TW, soil and food) in order to unequivocally assess the impact of the wastewater reuse practice under a wide spectrum of experimental conditions. Fruit quality parameters, including selected primary and secondary metabolites important for human nutrition and health protection will be also analyzed. Socioeconomic research activities including social perception and farmer experience on TW reuse for irrigation, economic value of TW and health-related effects of waterborne diseases, will be also provided by this project. Specific dissemination/exploitation strategies will be developed aiming at increasing social acceptance of the reuse practice.

Keywords: Advanced Wastewater Treatment Technologies; Chemical and Microbiological Contamination of the Agricultural Production Chain; Health Protection under Water Reuse.

AGRICULTURAL REUSE OPPORTUNITY OF MADIOUNA TREATED WASTEWATER (CASABLANCA, MOROCCO)

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Recently, Morocco has experienced a notable development with an acceleration of various anthropogenic activities in several regions and areas near cities and also in the rural areas. The emergence of new urban and suburban areas has contributed to an increase in wastewater production discharged into aquatic ecosystems often without any treatment. In consequence, environmental and health adverse effects are engendered on water resources. In this sense, the preservation of water resources has become a major environmental concern in Morocco. Thus, the country has invested in an integrated national management strategy of its resources through a number of actions including the launch in 2005 of the National Sanitation Program (NSP) for the construction of several wastewater treatment plants to protect its water resources. This program aims to effectively collect and treat wastewater through using efficient wastewater treatment systems for the agricultural reuse.

Hence, the wastewater treatment system in the Casablanca city area (central Morocco) is currently under development. But as many coastal towns most of its wastewater is emitted untreated or basically pre-treated into the ocean, even if the serious necessity for water in agriculture. In the south suburban areas of Casablanca, Madiouna locality, one of the current satellite towns, expands and produces an increasing quantity of raw wastewater discharged on a nearby watercourse, Hassar stream.

The local Public Private Partner LYDEC (Lyonnaise des Eaux de Casablanca) installed a wastewater treatment plant in April 2013 in Madiouna locality (South East of Casablanca). This treatment plant aims to protect the receiving environment of Hassar watercourse, to eliminate pollution and health risks to human as well as animal populations and finally to produce treated water for agricultural reuse. This treatment plant sized to 40,000 population equivalent (PE), with future expansion to 80,000 population equivalent. Indeed, this type of MBR treatment plant (Membrane Bioreactor), consisting of an intensive biological treatment coupled with an outer membrane filtration, has a great ability to simultaneously remove suspended solids and organic types of pollutants, inorganic and microbial.

The aim of our work is to verify the compliance of treated water quality to Moroccan standards of wastewater reuse for irrigation by assessment of the purification performance of this MBR treatment system, the first in Morocco and the second in Africa.

Monitoring conducted during the first 6 months of the station operation, from April to October 2013, has shown very high returns for key physicochemical parameters. The recorded abatement rate reached 90,90 % for COD, 99,25 % for BOD₅, 99,13 % for TSS, 95,59 % for Total Kjeldahl Nitrogen (TKN) and 80,20 % for Orthophosphate. While, the level of physicochemical quality (pH, conductivity and heavy metals) and hygienic quality (Fecal Coliform) of treated wastewater are found to comply with Moroccan standards for irrigation

waters. In contrast, the chloride (Cl^-) concentration does not comply with these standards and should be further examined as the risk of soil salinization has to be minimized. In addition, the low suspended solid concentrations in the treated waters of 3,72 mg/l should facilitate the water reuse in efficient irrigation technologies such as drip irrigation. Therefore, the established treatment system reaches good effluent qualities and the reuse of Mediouna treated wastewater is feasible. Indeed, the reuse of this wastewater in agricultural irrigation is well developed throughout the receiving environment of Hassar stream and especially downstream of his reservoir which stores water and refines his quality.

KEYWORDS: Mediouna; MBR; treatment; wastewater; reuse; agriculture.

URBAN WASTEWATER TREATMENT BY A CONVENTIONAL AND MODIFIED ACTIVATED SLUDGE PILOT SYSTEM

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Introduction

The treatment and reuse of urban wastewater, in particular for irrigation, is an increasingly common practice, encouraged by governments and official entities worldwide. Irrigation with wastewater is one of the alternatives that could be reliable and highly beneficial for irrigation and same time for agriculture. In fact, the wastewater can be an alternative to the use of clean water for agriculture, leaving fresh water used for other purposes including drinking water supply (WHO, 1989). Indeed, environmental and socio-economic advantages of this reuse can only be achieved if water through a WWTP (waste water treatment plant) that will eliminate the components liable to harm the environment and public health.

The aim of this study is to assess and monitor the physicochemical and bacteriological properties of urban wastewater and treated urban wastewater from a conventional and modified activated sludge pilot system during an experiment comparing, in which the main operational parameters were monitored and controlled.

Main results

Historical assessment of physicochemical parameters during this experimental campaign in both systems; the conventional and modified activated sludge plant; showed a variable performance in organic matter removal:

In conventional scheme the COD and BOD5 removal efficiencies were significant 94% and 97% respectively. This value shows an efficient treatment of the wastewater organic pollution by conventional wastewater treatment plant.

However, in the modified plant the COD and BOD5 removal efficiencies were highly variable depending on the plant configuration.

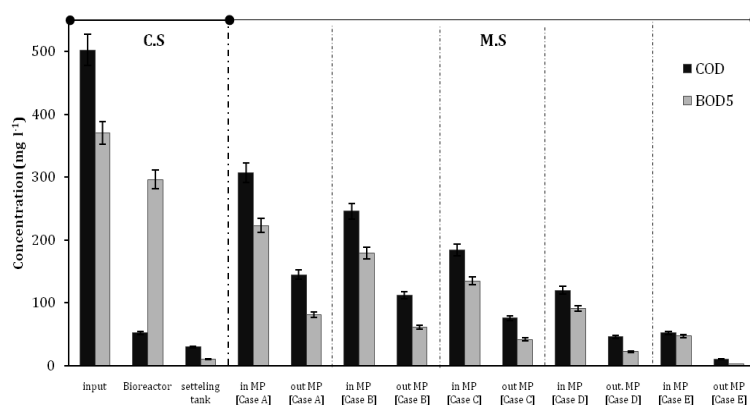


Figure 1. BOD5 and COD evolution conventional and modified pilot plant

The use of conventional scheme to treat wastewater is not suitable if the goal is agricultural reuse. In fact, this scheme is not selective in the removal of pollutants useful if the goal was the reuse. However the modified scheme is suitable in this case because it provide a selective and appropriate elimination of organic matter.

Conclusion

The results reported in this experiment suggest that the developed schemes provide a partial elimination of organic matter which could be interesting and useful when the objective was to reuse treated wastewater in agriculture. By contrast, when the objective was to discharge into environment the conventional system is the optimal choice because it provides high removal of organic matter.

KEYWORDS: Urban wastewater; activated sludge; modified activated sludge system; organic matter; performances.

Acknowledgement:

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NEW APPROACH FOR EXPANDING ACCESS TO SANITATION IN MOROCCO

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INTRODUCTION

In Morocco the water stress is growing more and more. However, this study was conducted to investigate the on-site treatment of wastewater in this area provides solution for sanitation. Treatment of wastewater by multi-soil-layering (MSL) system could be beneficial for Morocco.

The SML systems implemented in the Talat Marghen village, no far than Marrakech city In Morocco, could be used as a model for Moroccan rural areas.

The results of the technologies piloted implemented in Morocco will be study, according to managerial, socio-economic and technical aspects. The project asks for the best way to adapt the wastewater treatment systems for small communities in MENA region and some part in Africa.

MAIN RESULTS

This paper sets out, firstly, how the social approach was successfully introduced in this village where people are motivated to improve their living conditions. Result reveals that the users are satisfied with the social approach to treat and reuse their wastewater.

Secondly, and as the main challenge remaining for the management of sanitation, according to the results of the participatory diagnosis of Douar Talat Merghan, we followed a methodology included a comparison on the basis of key quantitative and qualitative criteria, between different modes of management options to implement. In our study case, we focus on management by local NGO, small private company and Public utility. The qualitative statistical analysis performed is based on mathematical modeling, performed using SPSS 17.01 software. The results of the statistical analysis showed the benefits of setting up a Local Association of villagers for the operations and management of the sanitation service.(Figure 1)

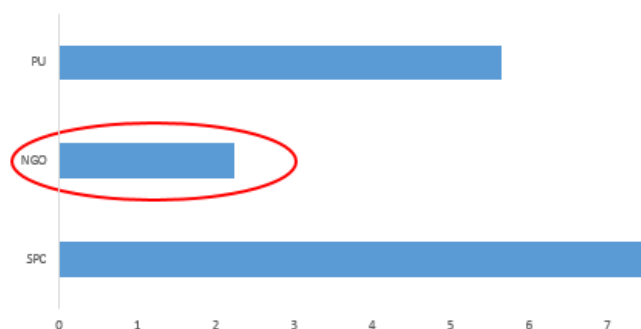


Fig. 1 Classification of the management Distances

Treatment of wastewater by MSL system could be beneficial for Morocco and MENA region. The technique of MSL system is a new concept in Morocco. This technique has been enhanced, structured and adjusted to have a service life, which is much broader than traditional sand filters [1]. MSL system is composed of locally available materials in rural areas such as soil, iron particles, jute or sawdust, charcoal and zeolite or alternative materials [2]. The MSL system constructed by two layers, permeable layer alternated with soil mixture blocks [3]. This technique came to overcome the many problems encountered in the conventional malfunctioning sewage treatment by the soil [4].

Finally, and as the SML is relatively new to Morocco, it seems that it can succeed in very rural and peri-urban areas. Indeed, the MSL technology has been successfully used in the pilot-scale and full-scale. In effect, excellent efficiency was obtained in the pilot and full-scale. MSL could be feasible to apply in full-scale systems at rural area in Morocco and MENA region, if sufficient conditions were supplied.

Acknowledgement

This project is funded by USAID (United States Agency for International Development) as part of the initiative FABRI (Further Advancing the Blue Revolution Initiative). The strategic objective of this project is to improve access to sanitation in rural and pre-urban communities in the MENA (Middle East and North Africa) by promoting concepts of decentralized wastewater management, and to strengthen local capacity to adopt operate and implement sanitation.

References

- [1] Chen X et al., J. Water and Environment, 1747, 2008, 6585.
- [2] Luanmanee S. et al., J. Ecological Engineering, 185, 2001, 199.
- [3] Masunaga T. et al., J. Soil Science and Plant Nutrition, 215, 2007, 223.
- [4] Yi-Dong G. et al., J. Desalination Water Treatment, 61, 2013, 2. 10.

PERFORMANCES AND MODELING BY WEST PROGRAM OF WASTEWATER STABILIZATION PONDS TREATMENT PLANT IN THE AREA OF CHICHAOUA (MARRAKECH- MOROCCO)

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The availability of land and climatic conditions, encouraged by the geographical location of Morocco, have pushed the country to adopt the wastewater stabilization ponds as the technical solution most adapted to the economic environment since the 1990s. Thus, many wastewater treatment plants have already been realized. This technology is characterized by low investment and operating costs with little technical expertise requirement. However, the use of large area remains a major constraint to this process, particularly in urban areas where land is expensive.

This paper aims to study the stabilization pond (WSP) plant located in Marrakech region, her performances and her constraints. Modeling of elimination processes has been also investigated. The stabilization pond plant is composed of tree anaerobic ponds followed by two facultative ponds. To characterize the nature of urban effluents, wastewater sampling was carried out between June 2015 and December 2015. Three samples were taken from the raw effluent at the entrance of the station, at the exit of anaerobic ponds, then at the exit of the two facultative ponds.

Raw wastewater are biodegradable, the ratio COD/BOD₅ equals 1,3. This result confirms the absence of industrial discharge connected to the domestic sewerage system. The purification yields observed for both treatment plant does not exceed 40% for BOD₅, 42% for COD, and 52 % for suspended solids (TSS), 14 % for Nitrogen and 8 % for phosphorus. The purification performances are low and variable and remain dependent of the season, especially for nitrogen and phosphorus. Fecal coliforms and streptococcus were eliminated at 3,9 & 3,4 log Unit.

The second part of the study is the calibration and validation of the established model by WEST program (World Wide Engine for Simulation, Training and Automation). We develop a dynamic mathematical model for the complete pond systems (WSP) of Chichaoua. The realization of this work led to the development of the establishment a database for WSP in the Haouz region.

KEYWORDS: Wastewater stabilization Ponds; WEST® system; CHICHAOUA; treatment efficiency.

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Topic 3

Food security, sustainable agriculture and forestry

DOES BIOFUEL THREATEN FOOD SECURITY?

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INTRODUCTION

The Biofuel is a fuel produced from biomass, namely organic material. There is two types of biofuel: bioethanol and biodiesel.

Biofuel is a renewable energy considered as a fossil fuel surrogate and a response to the oil price surge and its depletion. Its production is promoted by world policymakers to deal on one hand, with energy security and global warming and on the other hand, to strengthen agricultural and rural development. Beside the proven ability to reduce greenhouse gas emissions, biofuels have crucial negative effects. It competes for the limited agricultural resources with food production. Thereby, the rise of biofuels production means that the share of feedstocks production will increase to the detriment of food supply. Hence, the world agricultural commodity markets and the food security will be disrupted. The low country incomes will be the most affected. The surge of food price has triggered the food crisis of 2006-2008 which had large economic and social impacts. Moreover, the increase of biofuel feedstocks production had an environmental effect.

This paper tries to answer the following questions: does biofuel threaten human food security? Does it serve really the environmental cause aimed by the energy policies?

Main Results

In the space of 10 years (2006-2015) biofuel production and consumption have tripled. In 2015 biofuel production amounts 131992 million liter. During this period bioethanol represents on average 84% of the whole biofuel production, while remaining 16% accounted for biodiesel [1].

During the period the main bioethanol producers are United States with on average 53% of whole period production followed by Brazil (34%) and in a lesser extent by European Union (6%). The core feedstocks used are corn for US, sugar cane for Brazil, wheat, corn and barley for EU [1].

EU is the largest biodiesel producer (with an average of 68% over the period), followed mainly by US (17%) and Brazil (11%). The key feedstocks are rapeseed, soybean and sunflower for EU and basically soybean for US and Brazil [1].

The biofuel production increase translates the amount that escapes from a human food supply. During the period 2006-2011 the sugar cane produced for biofuel represents on average 18% of the world sugar cane production, while corn represents 11%, wheat and barley less than 1%. The world biofuel feedstocks production represent on average 12% of the world production of the period [1-2].

The soaring oil price during the period 2006-2008 increased the demand for biofuels and in the same way the demand for agricultural feedstocks. This latter competes with the food demand an especially cereal which is in continuous increase for many reasons relying to the world demographic increase and the change on food habit due to the globalization. Moreover, recurrent droughts and floods due to climate change reduced the food supply which exacerbate the inelastic demand for food and hence the surge of agricultural commodity price. In fact, the world food annual price index estimated by FAO has risen to 50% during the period 2006-2011, while the cereals index has risen of 68% and that of sugar over 46% [4].

This situation could disrupt and destabilize the economies of net agricultural importing countries, mainly those of low income and triggered a large macroeconomic disequilibrium. In fact, cereal import dependency ratio of low income food deficit countries during the period has risen about 409% 2006-2013[5]. Besides, the power purchase of people of low income countries had decreased mainly.

At social level the consequences are more dramatic. The surge of basic food price had limited their availability, increased hunger and poverty.

The massive production of biofuel shows some environmental side effects. The high use of pesticides and fertilizers in order to increase the productivity triggered soil erosion and water pollution. Moreover in order to increase arable lands and profit more from subsidies some farmers proceed to deforestation to produce more biofuel feedstocks what caused an enormous damage to the environment and biodiversity [5].

To sum up, the drawn balance of biofuel policy shows that the aims claimed of global warming and development are not respected. The side effects are larger than the supposed positive side. In 2011, the world committee food security called countries to revise the biofuel policy.

References

- [1] Food and Agricultural Policy Research Institute, U.S. and World Agricultural Outlook. Available from: <[ww.fapri.iastate.edu/outlook/2012/tables/5-Biofuels.xls](http://www.fapri.iastate.edu/outlook/2012/tables/5-Biofuels.xls)>
- [2] FAO, Food Balance Sheets. Available from:<faostat3.fao.org/faostat-bulkdownloads/FoodBalanceSheets_E_All_Area_Groups_1.zip>
- [3] FAO, Food price indices data (1990-2016). Available from: <www.fao.org/fileadmin/templates/worldfood/Reports_and_docs/Food_price_indices_data.xls>
- [4] FAO, Food security data. Available from:<faostat3.fao.org/faostat-bulkdownloads/Food_Security_Data_E_All_Area_Groups_1.zip>
- [5] Ajanovic A., Biofuels versus food production: Does biofuels production increase food prices? Energy, vol. 36, 2011, pp. 2070-2076.

STRATEGIES AND OPTIONS OF IMPROVING LAND AND WATER PRODUCTIVITIES OF CEREALS IN NORTH AFRICA IN THE CONTEXT OF CLIMATE CHANGE

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INTRODUCTION

Water shortage in the Mediterranean basin is a well-known and alarming problem. Increasing water scarcity is threatening the economic development and the stability of many parts of the region. At present, agriculture accounts for over 75% of the total consumption of water in the southern part of the basin. However, with rapidly growing demand it is certain that water will increasingly be reallocated away from agriculture to other sectors. Moreover, opportunities for the significant capture of new water are now limited. Most river systems suitable for large-scale irrigation have already been developed. Only a few major resources of renewable groundwater remain untapped and current resources are subject to overexploitation, with extraction exceeding recharge rate in many cases.

Many agricultural areas of North African countries are rainfed and a large proportion of the region's agricultural livelihoods are based on dryland farming systems. Rainfed production is dependent on low and extremely variable rainfall and, therefore, productivity is low and unstable. This is further affected by more frequent droughts and continuing land degradation.

Although many technologies have been developed by scientists in the region to cope with these environmental problems, the difference between the farmers' and potential achievable yields remain in general highly significant in both rainfed and irrigated areas. A large dissemination of the improved management packages can help close the observed yield gap. Moreover, because water shortage and drought will be more intense due to the effects of the climate, the maximization of land productivity should not be anymore the only objective; but more emphasis has to be put also on the improvement of the productivity per unit of water consumed by the crop. This will ensure water saving and higher global production. In this paper, strategies and options of water productivity increase are discussed.

MAIN RESULTS

Despite the problems of drought and water scarcity described above, there is still room for crop production increase in North Africa where the gap between the farmers' and the potential achievable yields remains high. As a matter of fact, studies conducted by ICARDA in West Asia and North Africa showed that the gap is high and it amounts, in rainfed and irrigated areas, 80-98% and 40-50%, respectively [1]. In fact, in the rainfed areas, the strategies of sustainable increase of crops yields are based on better crop and soil management and the improvement of genetic makeup of the cultivated plants to capture more water for use in transpiration, to use CO₂ more effectively in producing biomass and to convert more of the biomass into grain or other harvestable products. [2] showed that a combination between zero tillage, supplemental irrigation and adapted varieties of wheat can increase transpiration and improve the vigor and yield of the crop. Adapted varieties can also increase water and nitrogen use efficiencies. In the areas where there is access to limited irrigation water resources, water losses at different steps of water use in crop production should be reduced and the tradeoffs between land and water productivities should be made to optimize the use of both water and land resources [3] to sustain productivity and preserve natural resources. This can be achieved through the application of the required amounts of water and nitrogen at critical stages.

Moreover, raised-bed planting irrigation [4] technologies should be used to save water, improve physical and economic water productivities and protect the environment from chemical pollutions. Varieties with higher water and nitrogen use efficiencies should be developed [5]. Finally, we recognize that a single technique or technology effects are strongly affected by other production factors (variety selection, crop and land management) making an integrated management approach a more efficient way of meeting future food demands without over-using the limited available water resources.

KEY WORDS

Cereals, climate, water, management, productivity

References

- [1] Mustapha Pala et al., ICARDA, Aleppo, Syria., 2011, pp. 1-35.
- [2] Mohammed Karrou, African Journal of Agricultural Research, Vol 8(44), 2013, pp 5398-5404.
- [3] Mohammed Karrou and Theib Oweis, Agricultural Water Management, Vol 107, 2012, pp. 94-103.
- [4] Mohammed Karrou et al., Report no. 10, ICARDA, Aleppo, Syria., 2011, pp. 1-195.
- [5] Mohammed Karrou and Miloudi Nachit, Journal of Plant Nutrition, Vol 38 (14), 2014, pp. 2259-2278

DEVELOPMENT OF A LOW COST AND SUSTAINABLE PROTECTED AGRICULTURE STRUCTURE AND SUBSTRATE UNDER GCC CONDITIONS

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The GCC countries are considered one of the most water scarce region in the world, and facing over the coming years the most severe intensification of water scarcity in history. Protected agriculture area in the GCC countries is close to 13000 ha and most of it are using Pad-fan cooling system which lead to high energy and water consumption. An experiment was carried out between October 2015 and January 2016 in the research station of the International Center for Biosaline Agriculture in Dubai, UAE in order to assess the water and energy use efficiency of cucumber grown under a high technology greenhouse equipped by pad-fan and a low technology net house equipped by a mist system and also to develop a low cost and local substrate. Four varieties of cucumber (Alfrid, Brightsun, Cengel and RZ523) have been cultivated in four substrates (Coco-peat, Perlite, Mix of 1/3 perlite + 1/3 sand + 1/3 peat and Mix of 1/3 aggregate + 1/3 sand+ 1/3 compost) Our finding indicate that the greenhouse consumes about 1.5 time water and 84 time energy compared to net house. Obtained results in terms of yield showed that Alfrid variety produced about 16.7 and 19.5 kg/m² under local substrate (consists of 60% sand, 20% aggregate and 20% peat) and imported substrate (coco peat) respectively in the greenhouse. However it produced 21.5 and 23.1 kg/m² under local and imported substrate respectively in the net house. Zeco variety produced 16.3 and 14.5 kg/m² under local and imported substrate in the greenhouse however it produced 21.1 and 20.9 kg/m² under local and imported substrate in the net house. The projected water and energy use per hectare for cooling is raising more questions about the sustainability of cooled greenhouse in the GCC region. However net house system seems to be more sustainable and could contribute significantly in water and energy saving. Using local materials as substrate can be also a good practice to increase the productivity and farmer income and further more being less costly

KEYWORDS: *yield, irrigation, net house, hydroponic, variety*

GROUNDWATER GOVERNANCE IN A PUBLIC IRRIGATED PERIMETER (HAOUARIA-TUNISIA)

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In North Africa, public policies of groundwater use for irrigation face major limitations because of weak institutional set-up and lack of enforcement and legitimacy of the existing regulation. The aim of this paper is to explore a case of groundwater governance in a public irrigated area. The agriculture zone is located in the district of Haouaria in the Tunisian Cap Bon. This area was the seat of an overexploitation of aquifers caused by the high concentration of agricultural land and food industry.

This research exposes the different phases of the public perimeter's creation and tries to study the structure of the institutional management. Since 2000, a water association was installed in the perimeter. The mode of groundwater governance was evolved to institute a politic system of public's decentralization. This study revealed that the water association (GDA), in the research area, considers rather financial management since there are no restrictions of pumped water. We should also underscore that the control of well installation was absent. Therefore, this governance does not ensure a sustainable management of aquifer.

Key words:

Groundwater, governance, association, financial, sustainable

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CLIMATIC CHALLENGES AND WATER STORAGE OPTIONS FOR AGRICULTURE IN WEST AFRICA

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The reality of human-induced rapid climate changes is not any more challenged although the consequences vary widely with the local parameters and are still hard to predict, there is an undeniable trend towards increased variability of rainfall events in much of Sub-Saharan Africa. In this view, climate change adaptation will thus require additional resilience to dryspells, much of it through increased (and better distributed) water storage, it will also require adapting to more frequent floods and intensive rainfall. This calls for designing more “adaptable systems” focused on livelihood resilience. The concern for the adaptation to climate change has been instrumental in renewing the interest for sound agricultural water management investments that include water storage as a way to mitigate the impacts of increased rainfall variability.

In West Africa, rainfall variability is a critical issue for farmers, as water is a key limiting resource for crop and livestock production. Dryspell occurrences of 7, 14 and 21 days in two sites in West Africa (northern Ghana and Burkina Faso) show that dryspells of more than 7 days occur 70-95% of the time during the crop growing period. Dryspells of more than 21 days occur 7 - 8% of the time for longer season variety crops (100-120 days) and has not occurred during the cropping season of short season variety crops. Dryspell occurrences are linked to annual rainfall amounts, sequential below average annual rainfall occurring in the late 1970s and early 1980s coincided with the highest frequency of dryspells, especially towards the end of the season. This was mainly as a result of delayed rainfall shortening the crop growing season and affected yield production. Because of the high likelihood of the occurrence of short dryspells, coping strategies need to be put into place to avoid yield reduction. Coping strategies such as Zai and Demi Lune have been used in the Burkinabe site to overcome the short dryspells, and are therefore widely adopted. Increasing the potential to bridge dryspell from 7 to 10 days reduces the incidence of crop failure from 70-95 % down to 30-35%. Longer dryspells require alternative coping strategies and increasing the water storage capacity, through rainwater harvesting, dugouts and small reservoirs.

Observed trends in the historical rainfall show the long droughts during the 1970s and 1980s, after which the annual rainfall increased, but still at lower levels than before 1960. In one of the sites, climate variability has increased over the course of the period of observation and is not linked to the changes in annual rainfall. This indicates that climate in the area is becoming more variable and coping strategies are required. Climate change (CC) projection in the two sites using the CORDEX data show large differences from increasing annual rainfall to decreasing annual rainfall, mainly dependent on the selection of the CC model. RCP8.5 projections show larger deviations from the mean than RCP 4.5 projections, but with similar trends for the same model. A further analysis on the rainfall variability of these CC projections is yet to be done.

KEYWORDS: Dryspells analyses, climate variability, trends, water storage

Acknowledgement: This study was undertaken as part of the Building climate smart water storage and crop-livestock interventions in West Africa funded through the CGIAR research programme on Climate Change and Agricultural Food Security.

A SMART IRRIGATION SYSTEM BASED ON SOLAR ENERGY & WIRELESS SENSOR NETWORKS

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We take it for granted that water plays a key role in the continuation of life, but we make no real efforts to wisely use it. In fact, The World Bank, and for plenty of reasons, has estimated that the available water in the Middle East and North Africa (MENA) will be halved by 2050. Aware of these facts, and since agriculture represents 15% of GDP and 40% of employment, Morocco has made significant efforts to invest in increase provision of water. Also, the Green Morocco Plan dedicates a decent amount of resources to increasing the efficiency of water usage and the energy generation. However, some behaviors still need some reconsiderations. Indeed, huge amounts of water are used to get better yields and higher incomes. Therefore, a considerable pressure has been put on water resources, leading to a serious expected water deficit situation caused in a significant part of it by the irrational use of irrigation. Moreover, these irrigation systems are heavily dependent on fossil fuels that cause plenty of negative externalities which affects, badly, the environment.

As far as we are concerned, we worry about the future of Morocco, which motivated us to explore the possibility of merging several disciplines, such as smart irrigation, solar energy and wireless sensor networks, to create an autonomous, ecological and efficient irrigation system.

Indeed, we assume that the irrigation includes two main processes: the water provisioning process and the watering process. Our proposed system is described as a set of water supply stations and watering stations connected each other as a wireless sensor network. Each of these stations is equipped with sensors, wireless communication module and rechargeable batteries powered by photovoltaic solar panels (*see Fig 1*). The efficiency of the system depends on these components. Thus, it is important to check the compatibility of this equipment and respect the constructor requirements when being installed. Once the solar panels have been installed, the sensors have been calibrated and the control units have been connected, the irrigation manager must set up the watering characteristics and durations on the central irrigation station. Then, the process is very simple. Indeed, when the dryness of soil reaches a critical threshold the watering station detected it by soil moisture sensors, and sends an alert to the central irrigation station. The latter, check the level of water in the related water supply station. If it is empty, it commands the water supply station to fill the tank using its electric pump. Otherwise, the central sends the characteristics and duration of irrigation to the watering station which proceeds the watering. All the operations and alerts treated on the network are stored in the central station.

We propose an approach, for the communication and the routing between stations, utilizing the game theory for effective and efficient energy routing, which is a novel and challenging procedure for a smart irrigation network. We propose also some strategies based on elliptic curves cryptography for securing these transactions.

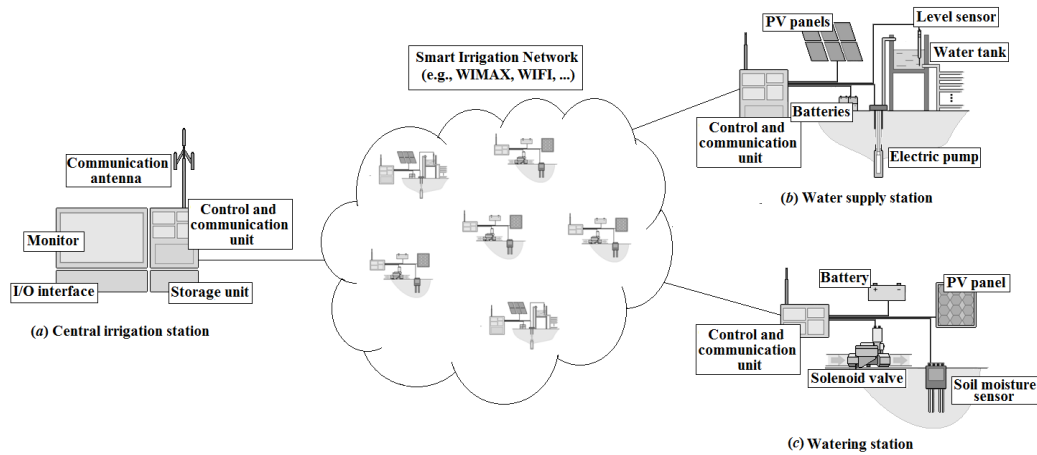


Fig 1: Smart Irrigation Network with Solar energy

The system will face the challenges of the agriculture in Morocco and will help to produce more, better and with less water, less fossil energy. The adoption of solar energy will minimize the carbon emissions in the irrigation activities by reducing the consumption of the fossil fuels. Moreover, it is possible to use the information stored by the system for a data analyzes or big data purposes. However, we plan to add more types of sensors to have much more control on the smart irrigation network.

KEYWORDS: Smart irrigation; Wireless Network Sensors; Solar Energy; Game Theory; Security

IMPROVED WATER USE EFFICIENCY BY DEFICIT-IRRIGATION: IMPLICATIONS FOR ECONOMIZING WATER USE IN *MEDICAGO SATIVA* L GENOTYPES

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Water scarcity is one of the important factors limiting plants productivity and growth in many arid and semi-arid regions in the Mediterranean basin. Because of the climatic changes, long-term water deficit will be more frequent in the future. Developing irrigation strategies based on crop water use efficiency is the best way to economize water use in agriculture in the future. The present study was carried out on several (*Medicago sativa* L.) genotypes from different origins to assess their adaptability to summer drought under field conditions. Landraces from Oasis Rc and Taf 2, and others from Atlas Mountain regions of Morocco, Dem1 and Dem2, an Australian Sir and American Mo varieties, were grown under field conditions at the experimental station of INRA, Marrakech. The plants were submitted to three irrigation regimes, 100% as control, 75% ETc as moderate water deficit and 50% ETc as severe water deficit. ETc (crop potential evapotranspiration) was calculated according to meteorological data of the station to determine the crop water requirement. Several agro physiological and biochemical parameters were assessed. The results showed that stress reduced plants growth, stomatal conductance (SC), chlorophyll fluorescence and chlorophyll content with significant variation between the studied genotypes. The water use efficiency (WUE) has been increased in stressed plants, especially in those from oasis region. The highest growth reductions were noted for the mountain genotypes, in which it exceeded 50% for dry biomass, than in the oasis ones in which it did not reach 37% for the same parameter. Therefore, we qualified these landraces as more drought tolerant and the former ones as less tolerant. These oasis landraces accumulated also the highest proline and nutrients in comparison to the others. Under severe water deficit, Sir and Mo varieties presented intermediate behaviors. For almost all of the assessed parameters, we suggested that the assessed parameters could be used as indicators for drought tolerance in many alfalfa genotypes and to determine the best irrigation strategy to enhance plants tolerance.

KEYWORDS: *Alfalfa, growth, proline, tolerance, water deficit, water use efficiency.*

Topic 4

Energy and climate change

**CONTRIBUTION TO THE STUDY OF THE DESALINATION OF
BRACKISH WATER BY MEMBRANE DISTILLATION COUPLED
WITH SOLAR ENERGY: PROJET PILOT AQUASOLAR
(BENGUERIR-MOROCCO)**

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Desalination market is booming in the world especially in the Morocco where major projects are underway; it concerns especially the preparation of water intended for human consumption from the sea and brackish water.

Exploitation of brackish waters to the Morocco can be done by combining desalination processes to a source of generally thermal and photovoltaic solar energy for distillation and membrane processes respectively.

Desalination processes are evolving, evolution driven by constraints of costs and availability of energy resources. Currently, reverse osmosis (RO) is the advanced technology for groundwater desalination. However, this membrane process is limited in terms of the osmotic pressure that increases to a high concentration of salts. Furthermore Membrane distillation is a new process that can be adapted effectively for the desalination of the water as it can be operate a high concentration of salts. The main advantages of Membrane distillation are in its simplicity and the requirement for only small temperature differentials to operate the process. Recently the membrane distillation has gained interest thanks to the improvements made to membranes, and the ability of coupling with low-temperature heat sources.

The objective of the work reported here is to study hybrid process coupling membrane distillation with the solar energy.

KEYWORDS: Membrane distillation, desalination, solar energy, brackish water, Morocco

Acknowledgement: The authors acknowledge the Institute for Research in Solar Energy and New Energies (IRESEN) for the financial support.

SOME LESSONS LEARNED FROM 26 YEARS EXPERIENCE USING SOLAR ENERGY IN DESALINATION AND WASTE-WATER TREATMENT.

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INTRODUCTION: It is well known that MENA region is facing a crucial problem of water. While the consumption is growing as a consequence of, among others, the growth of populations and the improvement of life style, this region is under a water stress. Indeed the challenge is to supply the needs in water for the current populations and to ensure the demands of the new generations. Moreover, these countries must ensure the energy needed for water production. In the case of Tunisia which is importing a part of its energy, only renewable energies can fulfil this role. Fortunately, Tunisia has an important potential of solar energy that can be used in desalination and waste-water treatment.

RESULTS: Our laboratory started in 1990 testing solar humidification in remote zones(Fig.1), and then extended the experiences to thermal MSF and photovoltaic R.O(Fig.2) desalination prototypes. It was found that: in the case of thermal desalination, the process begins to work properly around 11am and performance systems begin to decline rapidly from 15h as the temperature is not high enough. The main difficulties encountered with photovoltaic are the fluctuation of delivered energy and storage. Despite these difficulties, the performances of systems were encouraging.



Fig.1. Humidification plant of Hzag



Fig.2. Photovoltaic R.O

In the last decade, we used solar photo-catalysis in urban and textile waste water treatment for reuse. In the two cases, water was completely disinfected and may be used in irrigation of green and some kind of trees.

CONCLUSION: These experimental pilot-projects, although designed for research development, were tested out-of-door under real conditions and the effect of different

operational parameters was conducted. Two main conclusions are : Using solar energy for water treatment is feasible, and seasonal storage is necessary for better efficiency of all the processes.

Lessons learned from these 26 years experience are rich and should serve to provide data and advice other researchers and provide some guidance for decision makers.

KEYWORDS: desalination; waste-water treatment; solar energy; photovoltaic R.O

ASSESSMENT OF THE FIRST YEAR OPERATING DATA OF A RO BRACKISH WATER DESALINATION UNIT, KHENIFRA PLANT, MOROCCO

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The brackish water reverse osmosis unit described in this study belongs to the Khenifra BWRO plant, which is the first experience of surface water desalination in Morocco. The reverse osmosis unit has been operating with acid in the pretreatment and using an antiscalant for a short period, and using only the same type of antiscalant without acid in the pretreatment for the rest of the time. This work illustrates the graphical evolution of the daily operating data of the first year. A study of normalization and standardization of the data about the first year of the plant evolution, operating pressure, and system recovery are shown too, so the performance assessment can be indicated correctly. Moreover this study presents the graphic evolution of the real and theoretic brine LSI. The results obtained confirm that the application of the theoretic brine LSI values will be useful to design the BWRO plants, also the results show that this RO unit can operate without acid addition in the pretreatment.

KEYWORDS: Morocco; Brackish water; Reverse osmosis; Normalization; Desalination plant;

A SINGLE CHAMBER MICROBIAL FUEL CELL FOR ENERGY GENERATION AND WASTEWATER TREATMENT USING A NEW MEMBRANE

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Introduction:

In the context of the global energy crisis, MFCs (microbial fuel cells) are seen as a promising technology to meet the growing energy needs in a sustainable way since they can use bacterial metabolism to produce an electrical current from organic substrates. The search for alternative materials for their application in MFCs has become one of the main concerns among researchers in order to improve their efficiency. This work focuses on the development and optimization of a method for preparing a novel embedded membrane-cathode assembly based on ILs (ionic liquids) for its application in single-chamber MFCs.

Main results:

The assembly showed in the present study consists of embedding a polymer inclusion membrane based on the IL methyltrioctylammonium chloride into a carbon cloth cathode. The performance of this design is compared with that provided by an IL-based membrane placed between the anode and a carbon cloth electrode after being manufactured separately. Four step-by-step sequences for embedding the membrane are investigated to optimize its implementation. The new assembly was characterized by SEM-EDX and Mapping and assessed in single-chamber MFCs, allowing the power density to be increased from 51.5 mW m⁻³ to 613.3 mW m⁻³ for the ionic liquid investigated, which represents a significant improvement in terms of energy generation. This assembly also offers more compact and simpler design versus those configurations including IL-based membranes and electrodes as separate components in MFCs.

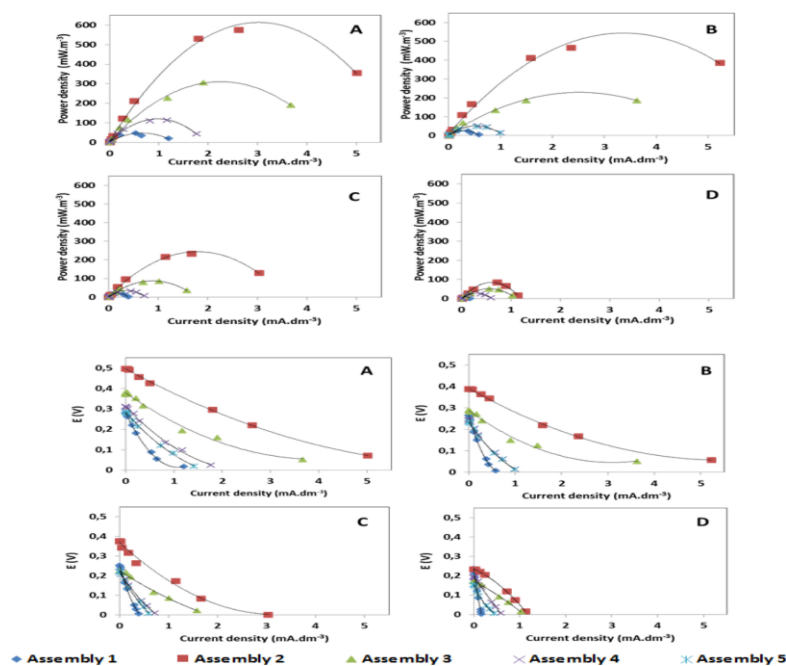


Fig. 1. Power (P vs I) and Polarization curves (E vs I) for each membrane-cathode configuration at different times. A) 24 h; B) 48 h; C) 72 h; D) 240 h.

After 10 days of operation, all assemblies reached high level of COD removal, above 70%, with the highest value of 76.1% for Assembly 3, while the base line only reaches 25.4%. Comparing the five types of assemblies in terms of wastewater treatment, the different designs do not present the large discrepancies observed for power generation, although among the assemblies mentioned, again Assembly 1 offers the lowest value with 65.2% of COD removal. Even Assemblies 4 and 5 offer good percentages of COD removal (74.6 and 70.5% respectively) although they show poor performance when it comes to energy generation.

Conclusion

In this study, a novel membrane-cathode assembly consisting of an ionic liquid-based polymer inclusion membrane embedded into a carbon cloth electrode was developed for its application as separator in single-chamber Microbial Fuel Cells. We have tested five different configurations and compare them. The optimal configuration (assembly 2) exhibited a maximum power of 613.3 mW m^{-3} , which is over 10-time higher than the power output achieved by the typical design based on the membrane and the cathode placed together after being manufactured separately (51.5 mW m^{-3}). We have also achieved interesting percentages of COD removal above 70% after 240 h of operation. These results show that this embedded membrane-cathode assembly can greatly improve the MFC performance for the ionic liquid studied.

Keywords: Microbial fuel cells, Green power generation, Embedded membrane, COD removal.

Acknowledgement:

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RENEWABLE ENERGY BUSINESS MODELS FOR DEVELOPING COUNTRIES

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As the current financial, environmental and social challenges increase, the world's leading groups seek more undiscovered methods as a solution to these challenges. Especially, developing countries, as they lack as explain by as Asif and Muneer (2007) the social-economical means to implement known renewable energy business models. As such they most find new and innovative ways to achieve these goals. Such is the case of the Dominican Republic (DR). The DR is primed to become a major proving ground for the viability of renewable energy in the Caribbean region. Although it still has major issues to address, Konold et al. (2015) emphasizes some of the key challenges in the DR, such as the high cost of electricity, generation peaked facilities, and a distribution system with major energy loss (42%) and instabilities in the power flow quality due to inadequate infrastructure and interruptions from natural disasters. Also, the DR's electricity sector is dominated by fossil fuels, with oil (46%), natural gas (25%), and coal (14%) accounting for 85% of the country's power generation as per Konold et al. (2015). In response to this, the government has made the international compromise to start the transition from a fossil fuel dependence economy to a renewable energy infrastructure by 2025 with a goal of 25% renewable sources in the generation of electricity because of the local wind potential of 100-10000 MW and solar potential of 5 to 7 kilowatt-hours per square meter per day. This paper will concentrate on comparing, through an extensive literature review, the existing energy business models in the DR to other fruitful and unsuccessful projects around the world (Canada, Costa Rica, Germany, Chile, Denmark, UK, USA, and China) to identify the drivers and barriers for a successful implementation of a new or adapted energy business plan for the DR and possibly other developing countries. After examining and comparing the case studies of Konold et al (2015), Del Rio et al. (2015), Beltramello et al. (2013), Asif and Muneer (2007), and Beaulieu et al. (2006), it can be inferred that several forwarding steps should be taken before the DR reaches the full potential of its renewable energy sources. The key steps to include: creating a renewable energy market and investment; education of the population in sustainable matters; law and policy creation and implementation for the furthering of renewable energy. The Renewable sources of the DR could fulfill the country's energy demand entirely and help create an energy economy and business with the rest of the Caribbean. As Konold et al. (2015) highlights the tremendous solar potential of the DR (ranges from 5 to 7 kilowatt-hours per square meter per day (kWh/m² /day) throughout most of the country, and approaches 8 kWh/m² /day in some regions. It is greater than Germany, that has few locations above 3.5 kWh/m²/day, and more than Phoenix, Arizona (USA) famed for its solar potential, that possesses an average of 5.7 kWh/m²/day. However, raw potential is not the only decisive factor, all researchers (Konold et al (2015), Del Rio et al. (2015) Beltramello et al. (2013), Asif and Muneer (2007) and Beaulieu et al. (2006)) agree that the possession of the natural resources does not guarantee the transition or the successful utilization of the renewable energy. However, each has a different approach to the implementation of renewable business models. Beaulieu et al (2006) points towards economics schemes being the key factor for success. While, Del Rio et al. (2015) and Asif and Muneer (2007) indicate that without a renewable energy market the transition and projects will not succeed. On the other hand, Konold et al. (2015) explains that it is the governments that should be responsible for the transformation to a renewable energy economy. Although, all factors are important; any one by

itself does not guarantee the success. However, the combination of all the factors and more, is in reality the conglomerate factor that tips the balance towards success. The difference in the conception, approach, design, and implementation of each of the case study is linked directly to the country, the economic situation, the government disposition and the consumer or population knowledge of the renewable energies and technologies. Future work in the area must be done to develop renewable energy business models which encompasses the whole life cycle of the project.

KEYWORDS: *Developing country, Energy Infrastructure, Renewable Energy, Renewable Energy Business Plan.*

ENERGY PRODUCTION BY CONTINUOUS MICROBIAL FUEL CELL USING A NEW MEMBRANE BASED ON IONIC LIQUID

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Introduction

Many research studies point to Microbial Fuel Cells (MFCs) as a promising green alternative to fossil fuels. They use the electrons produced by bacteria when degrading organic matters to generate electricity. Among their applications, wastewater treatment is one of the most important. Thus, it is a key factor to find a configuration that allows microbial fuel cell to be operated in steady-state continuous mode.

Main results

In this work, a single chamber air-cathode Microbial Fuel Cell configuration has been designed to produce electricity and for wastewater treatment purposes in continuous mode: vertical set-up. Apart from the design itself, another important novelty is the use of a polymer inclusion membrane based on ionic liquid, Triisobutyl (methyl) phosphonium tosylate, $[P_{14,14,14,1}^+][TOS^-]$, assembled with the cathode as a proton exchange membrane. Two feed flows were investigated $0,25 \text{ mL} \cdot \text{min}^{-1}$ and $0,35 \text{ mL} \cdot \text{min}^{-1}$. It has been studied the effect of the configuration and the feed flow in the performance of the MFC in terms of power output and wastewater treatment. Promising results have been obtained, achieving a power density of $12.3 \text{ W} \cdot \text{m}^{-3}$, and 60% of COD removal.

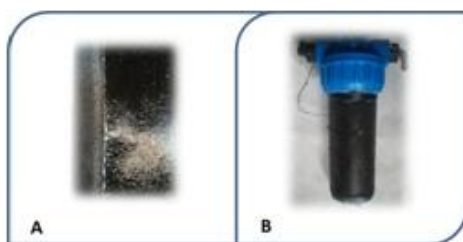


Figure 1. A) Polymer inclusion membrane based on $[P_{14,14,14,1}^+][TOS^-]$ /Cathode assembled; B) Vertical Feed Flow MFC.

Conclusion

The application of a newly developed membrane based on ionic liquid in microbial fuel cells at a continuous flow present a low cost biotechnology that combines energy production and wastewater treatment. Their performance was comprehensively examined at different flows, we can conclude that Triisobutyl (methyl) phosphonium tosylate offers a good

maximum power output and COD removal. An increase in the feeding flow does not improve the performance of the MFC, The best results have been obtained at 0,25 mL .min⁻¹.

KEYWORDS: Microbial fuel cell, Energy production, Wastewater treatment, Polymer inclusion membrane, MFC configuration.

Acknowledgement:

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PUBLIC PRIVATE PARTNERSHIP FOR IMPROVING ENERGY EFFICIENCY OF WALA LIB PUMPING STATIONS IN MADABA GOVERNORATE – JORDAN

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Introduction

The Water Authority of Jordan (WAJ), including the water Companies, operate the water pumping stations across the country to distribute the water among the citizens of Jordan. However, according to the financial figures from WAJ and the Jordan Electricity Company, WAJ is considered as the biggest energy consumer in Jordan. This is due to several reasons such as the poor conditions of the pumping units, poor operation and maintenance procedures and lack of qualified and trained operators. The water companies of Jordan pay for the electricity approximately 150,000,000 JOD per year which represents, as of 2013, approximately 50% of the total operating expenses of the companies.

Following the changes in the electricity tariff system occurred in 2013, electricity prices for the water sector will increase annually from 76 fils in 2013 to 133 fils in 2017 which will take the total electricity expenses to 250,000,000 JOD per year, making it unsustainable for the Jordan water sector to run the water facilities located across the territory of the Kingdom. Thus, the modernization of the water pumping stations will lead to greater energy efficiency, through modern pumping technology which will lead as well to reduce the financial costs of the Water Authority of Jordan. Adding to that, the modernization of the water pumping stations will lead to reduce the water losses in the water systems and the CO₂ emissions to the environment.

However, due to the lack of sufficient financial resources for WAJ to modernize the pumping stations in Jordan, WAJ has started pursuing different possible options to improve the performance of the water pumping stations. One of the effective and well known ways to modernize the pumping stations is to involve the private sector in the management of water systems through performance based contracts to improve the energy efficiency of pumping stations and to enhance the capabilities of the operation staff. This paper presents a pilot Public Private Partnership (PPP) project to improve the energy efficiency of Wala Lib pumping stations in Madaba governorate in Jordan on performance basis. The project is implemented by Miyahuna and a private consortium consists of Engicon O&M and Wilo SE in cooperation with the Water Authority of Jordan and the German Agency for International Cooperation (GIZ). A special mechanism to share the saving between the public and the private sector was developed based on the quantity of the water pumped and the energy saving per cubic meter. The main objectives of the project are to improve the energy efficiency of the pumping stations, to reduce water losses, to provide better services and to enhance the staff performance through providing specialized capacity building program. The project duration is five and half years including the preparation phase. The official performance period started in January 2015 and the results of the first year of operation showed high energy saving in the two pumping stations. The energy saving percentages in Wala and Lib pumping stations until end of December are 13% and 39% respectively. These percentages are above the saving percentages required by the contract.

Through this paper, I will shed light on the methodology used in this project, the project results up to the date of the presentation and the advantages as well as the disadvantages of PPP approaches for the management of water systems.

Key words: WAJ, Engicon O&M, PPP, Energy Efficiency

COMBINING A TWO SOURCE ENERGY BALANCE MODEL, AGGREGATION APPROACH AND MODIS DATA TO ESTIMATE AREA-AVERGED TURBULENT FLUXES DURING THE AMMA EXPERIMENT

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Estimates of turbulent fluxes (ie sensible and latent heat fluxes H and LE) are of primary importance in many research areas such as: meteorology, climatology, hydrology, agriculture, etc ... Over homogenous surfaces, these fluxes can be, and have been measured using point-sampling measurement devices such as Bowen ratio or eddy covariance. However, over heterogeneous surfaces, estimating of H and LE is not an easy task. Indeed, the heterogeneity caused by the contrast in vegetation cover and type—and/or by precipitation can generate a large spatial variability of H and LE.

The main objective of this work was to estimate the turbulent fluxes over a 3km heterogeneous transect in Wankama Niger basin, by combining a Two-Source-Energy-Balance (TSEB model) , an aggregation approach and MODIS satellite products including the albedo, surface temperature and leaf area. This transect contains three dominant cultures: Millet, Savanna and Fallow. Each field was equipped by an eddy covariance system to measure the turbulent fluxes and a micrometeorological station. Additionally, a large aperture scintillometer was installed over the transect to measure area-averaged of turbulent fluxes. Firstly, the TSEB model was validated at the field scale by comparing its output against the eddy covariance measurements. The results showed a good ability to reproduce the flux LE with an RMSE of 78.59 W/m², 63.5 W/m² and 74.9 W/m² for, millet, savanna and fallow, respectively.

Then we combined the TSEB model with an aggregation scheme to estimate averaged turbulent fluxes over the length of the transect. To validate this approach, the turbulent fluxes measured by the large aperture scintillometer were used. In spite of the obtained scatter, it can be concluded that these results demonstrate the potential of the proposed approach to reproduce LE across the large scale with a RMSE equal to 75.36 W / m².

Our current work involves integrating satellite products (surface temperature, albedo and leaf area) to estimate the turbulent fluxes at the regional scale. The first results of this approach are very encouraging.

Keywords: Heterogeneous, TSEB, Aggregation, MODIS, Eddy covariance, scintillometer, turbulent fluxes, Ts, LAI, satellite.

KINETIC SOLAR DRYING, EFFECTIVE MOISTURE DIFFUSIVITY AND ACTIVATION ENERGY OF MOROCCAN ROSEMARY LEAVES

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Water contained in foods allows the proliferation of microorganisms and the development of chemical reactions that deteriorate the product. This experimental study is focused on the influence of the drying parameters on the water loss of the fresh rosemary leaves, it presents the results of an experimental study of the drying kinetics of rosemary.

The Rosemary (*Rosmarinus officinalis*) is a medicinal and aromatic plant of the family Labiatae, pushing on chalky soils in Mediterranean countries, such as Spain, Morocco, Tunisia, France and Italy. Its leaves contain an essential oil to which it owes its properties in the digestive system.

Aromatic and medicinal plants, including rosemary, can be presented in tow basic forms; fresh and dried, dried form makes storage and transport easier compared to fresh herbs. So, the most popular way of conserving plants is as dried herbs.

The rosemary drying pocess may be conducted by using solar energy; it is one of the oldest applications of solar energy to preserve food. The use of solar energy in drying is becoming an important and viable alternative since it decreases consumption of conventional energy, and improves production efficiency. Drying leads to reduce the water activity from a natural or industrial product in order to reach the standard specification moisture content.

The aim of this study were to determine the effect of drying air temperature and air flow rate on the drying kinetics of the rosemary leaves, the effective moisture diffusivity and activation energy of rosemary leaves during thin layer drying process.

The experimental study consists of an indirect forced convection solar dryer, with a solar air collector, an auxiliary heater, a circulation fan and a drying chamber. This technique is tested at the laboratory of the "Ecole Normale Supérieure" of Marrakesh. The mass of rosemary leaves used in drying process was (10 ±0.1) g,

The drying kinetics was studied for four air temperatures (50, 60, 70 and 80 ° C) and two airflows drying (300 m³/ h and 150 m³ / h) for an ambient temperature in the range of 26-37 °C. The increase of temperature reduced the drying time, the variation in the drying time according to the drying air flow rate is not very important for high temperature and become more important for lowest temperatures.

In order to select the best mathematical model for the drying curves, nine models were studied; they are classified into theoretical, semi empirical and empirical models (Newton, Page, Tow-term, Henderson and Pabis, Diffusion approach,Logarithmic, Wang and Singh, Verma and all and Midilli-Kucuk)

The experimental results are used to determine the characteristic curve of drying. Midilli küçük model was found as best fitted thin layer drying model when simulation was done for all the drying data. In the ranges covered, the values of the effective moisture diffusivity (D_{eff}) were obtained between $9.74 \cdot 10^{-11} \text{ m}^2/\text{s}$ and $1.48 \cdot 10^{-10}$ from the Fick's diffusion model. The Arrhenius relation, with an activation energy value of 54.37 kJ/mol, expressed the effect of temperature on the diffusion coefficient.

KEYWORDS: kinetics solar drying; characteristic curve; Model; diffusivity; activation energy

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Topic 5

Society and Sustainability

ROLE OF NON-GOVERNMENTAL ORGANISATIONS (NGOS) IN ADAPTATION AND MITIGATION OF CLIMATE CHANGE IMPACTS: CASE OF DEVELOPMENT CENTER OF TENSIFT REGION (CDRT-FORUM OF MARRAKECH)

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Climate change is a problem with global dimension. The fact that it is at the crossroads of scientific, economic, social and political issues explains the necessary involvement of everyone in its adaptation and mitigation. The role of non-governmental organizations (NGOs) is essential. The place given to them by the international community and their long experience ascertain their importance in addressing environmental issues.

The Development Center of Tensift Region (CDRT) is a Moroccan NGO founded in 1998 in order to promote the development of the Marrakech-Safi Region. CDRT is recognized as public-interest organization by ministerial decree since 2005. It has since 2010 a status of Active Organization Observer to the United Nations Framework Convention on Climate Change (UNFCCC) and participates actively in Conferences of the Parties (COPs).

The experience of CDRT in adapting and mitigating the impact of climate change is rich and diverse. For example, the Center is a host institution of the African Climate Change Fellowship Program (ACCFP) since 2008; It conducted studies on Food Security and Climate Change in Morocco in collaboration with NASA and the University of Marrakesh (UCAM) and developed a security and combustion improved system of gas furnaces (MOR/OP3/1/05/06) in collaboration with UNDP-GEF. These efforts were crowned by winning the award "ALM Ecology Trophy" in 2010.

Our contribution is to highlight the experience of CDRT in addressing issues related to climate change. We will especially focus on pilot projects of CDRT such as : "the project of the evaluation of the energy plant *Jatropha Curcas* as a way to promote renewable energy in the Mediterranean region"; "The project of rehabilitation of the old mine Kettara with a cover made of limestone phosphate discharges"; "The project to support natural resource participatory management in the Toubkal National Park (TNP) and the province of Haouz"; "The contribution to the improvement of environmental quality in the biosphere reserve of the southern oasis of Morocco"; "The project to fight against pollution and improve products quality in the pottery village of Marrakech" and the current project "Climate Change: towards a collective mobilization (2CMC)." The CDRT could realize these projects through effective cooperation. A focus will be on its partnership approach with the public and private sector, at national and international level.

Keywords: *climate change; NGOs; CDRT; partnership.*

SUSTAINABLE DEVELOPMENT OF CITIES FACE OF THE CHALLENGES OF CLIMATE CHANGE

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Officially launched by the Brundtland Report in 1987, sustainable development is often presented as the solution to reconcile economic, social and ecological dynamics. Sustainable urban development then sends the internalization process of sustainable development in urban planning. The urban problem has been relatively neglected until the 1990s, in part because the city is sometimes considered a source of difficulties likely to be resolved by rebalancing the habitat for the campaigns, on the other hand because this medium is so complex that we can not adopt simple solutions.

Sustainable urban development is now facing a number of economic, social and environmental problems. The Brundtland report shows that the main Urban Challenge is played in the South, where the growth of cities, combined with the lack of infrastructure and environmental degradation, led to very critical situations for vulnerable populations. He mentioned the problems of the energy consumption of cities, auto transport, urban sprawl, but also the implications of climate change. The challenges of climate change require today to reduce emissions of greenhouse gases and to take appropriate measures for mitigation and adaptation. These challenges arise especially at the city level. Cities are indeed a high concentration of people and activities, but also a high sensitivity to climate change.

This article discusses the question of climate change in the urban context. It begins by presenting the different aspects of environmental vulnerability related to climate change in urban areas, and then treat especially its major implications for cities in developing countries and specific adaptation measures. Specific issues such as energy, water, transportation will be analyzed. This work will show the importance of the issue of urban governance, dialogue between different actors in urban areas, and the effective participation of vulnerable populations.

Keywords: *Sustainable Development, Climate Change, City, adaptation*

Selected Bibliography:

SOUAMITaoufik et VERDEIL Éric.. « Concevoir et gérer les villes. Milieux d'urbanistes du sud de la Méditerranée », Paris : Economica. 2006

BOISVERT Valérie, « L'empreinte écologique : un indicateur de développement durable ? », le Développement Durable, Presses universitaires de Rennes, Rennes, 2005.

PASSET René, « Comment parvenir au développement durable ? » Problèmes économiques, 23 février 2000.

AN INTEGRATED DEVELOPMENT OF THE WATER AND ENERGY SECTORS TO FACE CLIMATE CHANGE IN THE MAGHREB COUNTRIES: SITUATION AND PROSPECTS

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Based on the results of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the Maghreb region is threatened by climate change, which could significantly increase the relevance of water development policies, given that economic growth of the majority of Maghreb countries is closely related to water resources.

The Maghreb countries are facing many challenges related to a decrease in renewable water resources. They have to manage these resources carefully, to minimize water loss and to respond to the most important demand.

Furthermore, the climate change has an impact on the hydro energy production, reflected in decreased water storage and energy production across dams.

To face these challenges, countries have built diverse infrastructures and created water institutions. In addition, the Maghreb countries (Morocco, Algeria, and Tunisia) have adopted climate change adaptation strategies that highlighted many alternatives to resolve water scarcity under climate change threat.

The adopted alternatives and solutions include economic irrigation options and non-conventional resources with high energy consumption such as water desalination and water reuse. In addition, switching towards efficient technological options and modern irrigation systems increase the energy needs in the agricultural sector.

Therefore, developing non-conventional resources and modern irrigation systems will increase the energy consumption in the water sector and the development of the water sector will be strongly related to the energy sector development. Furthermore, the interactions and synergies between the water and energy sectors require an integrated planning policy and more collaborative mechanisms between the sectors.

In this context, the Maghreb countries (Morocco, Algeria, and Tunisia) have developed a new energy strategy on the basis of economic options. The new energy strategic objectives are aimed at securing the energy supply, ensuring accessibility of energy at the lowest possible cost and promoting energy efficiency in all economic and social activities.

The aim of this paper is to analyze the strategic issues of the integrated development of the water and energy sectors, as well as the level of interactions between water and energy that are considered in the sectors policy management and planning in the Maghreb countries.

The analysis is focused on the case of Algeria, Morocco and Tunisia. It proposes ways to improve the interactions and synergies of this system in the Maghreb countries. In addition, the analysis will allow to identify some strategic recommendations and orientations to promote an integrated development of the water and energy system considering interactions and synergies between these sectors.

Keywords: Water, Energy, Climate Change, Integrated Development, Maghreb

URBAN DRAINAGE AND CLIMATE CHANGE: TOWARD THE BEST MANAGEMENT PRACTICES

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It has become now clear that Climate Change (CC) is a reality across the globe. Regarding urban drainage and the CC, some studies have concluded that the risk of flooding in urban areas would increase in the future at least 2 times (Ashley et al. 2005). This will have a significant impact on maintaining the service level of the urban drainage systems.

In this context, an approach based on source control, is often less privileged in the traditional approach to design drainage systems, it can become a key element in implementing new approaches with control volume and the range of rainfall events, especially for frequent events (NRC, 2003; NRC, 2004; MOE, 2003). The integration of source control in urban areas also underlies a redefinition of design concepts across urban development (Engineers Australia, 2006)

The term “Best Management Practices” (BMPs) or more recently LID (Low Impact Development) presents new more holistic trends for stormwater management. The objective of this approach is to encourage infiltration and locally control the flow rates and volumes for frequent events. Subsequently, these trends have profound implications for the planning, design, and financial and operational aspects of drainage networks (Mailhot et al. 2007).

In a context of climate change and considering the percentage increase of flows and runoff volumes that can be expected, the question that now arises is what extent and how effectively the different types of techniques can be used.

This article aims to:

- 1) Provide an overview on the technical approach related to the Best Management Practices;
- 2) Present innovative solutions; tested in some developed countries; for an improvement of urban drainage system services to reflect the new climate expected in the coming decades.
- 3) assess the effectiveness of such measures in order to offset the additional risks posed by CC in flood and discharge of rainwater;
- 4) Present the foreseeable gain following the introduction of alternative techniques as adaptation measures to CC.

KEYWORDS: Climate Change; urban drainage; stormwater management; adaptation, best practices.

OPPORTUNITIES IN THE WATER-ENERGY-FOOD SECURITY NEXUS: EXPLORING NOVEL WAYS TO INCREASE BENEFIT AND COOPERATION IN THE EASTERN NILE BASIN

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Water, energy, and food are interrelated systems which face numerous challenges including growing population, economic crises, poverty, hunger, and climatic uncertainties. Meeting these challenges requires a paradigm shift and a better understanding of how these three resources form a nexus, with quantifiable interconnections (Daher, 2012).

Demands for water, energy, and food are increasing at the same time that available natural resources are increasingly degraded and in scarce supply. This challenge is particularly acute in developing regions with rapid economic growth, such as the Nile Basin in Eastern Africa. Several large infrastructure projects in the region are changing the hydro political regime in the Eastern Nile Basin generating a range of transboundary nexus opportunities (Ringler, 2015).

The Eastern Nile Basin: Nile River basin without the Equatorial Lake basin. Its area is 1.8 million km² with Population about 149 million, Located in 4 countries: South Sudan, Ethiopia, Sudan and Egypt and Divided into 4 sub-basins (van der Krogt, 2014).

Ethiopia is the most upstream country, its highlands generate over 86% of the Nile waters (ENTRO, 2015); supplying all the water and lower riparian's Sudan and Egypt basically consuming all the water. Sudan is the largest riparian in the whole basin, it consumes 97% of all the water for agriculture production, it has the largest irrigation scheme on earth. South Sudan contribute to huge loss of water through the Sudd one of the biggest wetlands on the earth where water evaporated, that's one of the reasons why the white Nile contributes is relatively little to the flow in Egypt and Sudan. Egypt completely depend on the Nile, the national food production is based on irrigation from the Nile. Egypt, Sudan and Ethiopia in the current years had economic growth rates between 8 and 12%, going to be a newly industrial countries within the next 20 years, which means more water demands and increasing energy demands (Ribbe, 2013).

However, transboundary management of the Nile Basin has rife with conflict between the riparian countries. While these conflicts have been addressed using negotiation or threat of force in the past, there is still potential for water war in the Nile Basin. Opportunities created by the water-energy-food nexus include a potential for new arrangements that can optimize benefit sharing among riparian countries, increase cooperation and minimize violent conflict.

Looking at Collier- Hoeffler model which used to predict the occurrence of conflicts as a result of empirical economic variables in African states given the sporadic civil strife in Africa can help to analyze the transboundary challenges (Rahman, 2014). Specifically, the objectives are to:

Benefit sharing: by looking at Eastern Nile Basin as one country. Sudan irrigate the land using energy from Ethiopia (Renaissance Dam) and water from Egypt after relooking at the Nile water agreement of 1929, Ethiopia contribute with energy and Egypt augments its water supplies from non-conventional sources over 15-20 years. The three countries agreed on the Sudanese and Egyptian shares of electricity generated by the Renaissance Dam, expected to reach 6,000 megawatts, a mechanism for resolving conflicts, and compensation in case of

damages. The three signatories will be bound to the recommendations of the firms that will assess the impact of the dam on the water provision in Sudan and Egypt (Dabanga, 2015).

Currently, the Eastern Nile Basin sharing and management principles derive from the Nile Water Agreement of 1929, Egypt is guaranteed the lion's share of the Nile waters with access to 55.5 billion cubic meters of water, out of a total of 84 billion cubic meters. There are various points of contention, the fundamental being that the agreement is colonial, inequitable and currently not fit for purpose (Vasagar, 2004). The shortage of water and water resources in Ethiopia and of course Sudan has prompted those countries to take a second look at Egypt's access to the Nile (Rahman, 2014).

To conclude, the Nile Water Agreement of 1929 and its attendant practices and issues (political, economic, and social) should be critically evaluated in the light of other (successful) transboundary water management systems. Principally, the issues of fairness, peaceful cooperation, and shared interest should be considered. A new framework should be established to consider the issue of the energy needs of Ethiopia and food and water for Egypt and Sudan. The issue of sustainability should also be incorporated. Specifically, new ways should be explored in order to allow Ethiopia to derive energy within safe ecological limits; allocation to Sudan should be increased over time while Egypt takes steps to augment its water supply from non-conventional water resources.

KEYWORDS: *Water*; Energy; Food security; Eastern Nile Basin, Nexus.

MODELS FOR CLIMATE CHANGE IMPACTS ON THE PEOPLE MOVEMENT THROUGH MOROCCO TOWARD EUROPE

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According to recent reports, land temperatures over Africa will probably rise faster than the global land temperatures average, particularly in the Northern arid regions, along with a reduction in precipitation. Thus, Morocco is a country highly vulnerable to extreme weather events that can have negative consequences for biodiversity and the conditions of human life. This article stems from on the research inside MEDCHANGE, an European 7FP project under the Marie Curie International Research Staff Exchange Scheme (IRSES). three researchers living eight months in Morocco have noticed and assessed how climate change is impacting on the rural development and socio-economic stability of this country, Sahel region and Sub-Saharan area, focusing preferentially on population who more suffer for this cause and who are forced to emigrate. A mixed method was necessary posed to tackle the work. A quantitative methodology is implemented in the data analysis of coupled systems involved in this issue and a qualitative methodology applies ethnographic methods such as participant observation and semi-structured personal interviews to key informants. These ethnographic tools have been developed following Nussbaum's capabilities approach. In this way we ensure that people who may have migrated for socio-economic reasons might also be a consequence of climate change even though they would not define it as such. As for the quantitative methodology, climate data are used to set up a complex model, the coalescent economy model stemmed from hydrological model, the agriculture yield model, and the industry and tourism model. The coalescent economy model, aligned with the welfare expectations of the population and regulated by Nussbaum's factors, can stochastically estimate the decision to emigrate. General Circulation Models, locally focused by downscaling methods, can project toward future the atmosphere dynamics in the study area. So, different scenarios can be considered to training the coalescent model to envisage the emigration response to the climate variability in a future horizon. This communication is a summary of a project developed during three years of researcher secondments in Morocco and Spanish, and carried out under a schema of mixed methods, highlighting the importance of multidisciplinary work among researchers from different academic fields and countries, as well as universities, civil society, non-governmental organizations and international organizations on an equal basis Southern –Northern collaboration.

KEYWORDS: Climate change; hydrological model; coalescent model; mixed methods; emigration; downscaling;

POSTER PRESENTATIONS

Topic 1

Water sustainability and climate change

ASSESSMENT OF UNDERGROUND WATER QUALITY IN ENVIRONMENT ADJACENT TO PETROCHEMICAL

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The adverse effects of the hazardous material resulted from the industrial activities on the human health and environments have been documented as well. Petrochemicals factors is among several of industrials process which contribute in the contamination of the environment. In the term of heavy metals contamination, the petrochemical industries represent one of the main sources for generation of these toxics into the environment. This study aimed to assessment of Underground Water Quality which included chemical (heavy metals), physical and microbiological parameters (E. coli, Pseudomonas aeruginosa, sulfite reducing clostridia, and yeast and molds) in Environment Adjacent to Petrochemical Industry. The underground water samples were collected from the surrounding area of General Company of Chemical Industries (GCCCI) at Abu-Kammash, Libya. The concentrations of heavy metals were conducted using inductively coupled plasma (ICP-Mass) Spectrometry. The results revealed a detectable concentrations of heavy metals as well as pathogenic bacteria in the water samples. Heavy metals concentrations were more than that recommended for drinking water. Yeast and molds were more abundant than Bacteria in all water samples.

Key words: toxic elements, soil, Zuwarah, Abu-Kammash, GC-MS, ICP-Mass

TRADITIONAL KNOWLEDGE AND ITS INNOVATIVE USE TO FACE WATER RESOURCES SCARCITY IN RURAL AND URBAN ECOSYSTEM

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Climate change, ecosystem collapse, cataclysms, the end of civilizations are conditions that humanity has had to face numerous times. People have had to deal with the unpredictability of the environment and the variability of the climate. The conditions of climate variability, ecosystem degradation and natural disasters imposed a deep insight in managing resources and the invention of cheap technologies and processes that were not destructive. In several climates and environments, incredibly tenacious cultures were able to use locally available materials and renewable resources. They applied the principles of nature: sun, wind, shadow and humidity to start positive interactive processes and amplify useful dynamics. These very conditions forged locally adapted knowledge capable of responding to adversity with appropriate techniques for water harvesting and distribution, soil protection, recycling and optimal energy use. Such techniques constitute a huge reservoir of biological and cultural diversity and of sustainable knowledge, show how to intervene in perfect agreement with the environment, highlighting its potential without exhausting it. The paper demonstrates the value of traditional knowledge in the field of the Management of water resources under scarcity. The significance of the practical and cultural dimensions of this knowledge based on a systemic vision of the human-nature interactions taking into account the environmental, economic and socio-cultural aspects of landscapes is underlined. Each Traditional Knowledge is not only an expedient to solve a single problem, but it is an elaborated and multipurpose system realized through the integration between the society, the culture and the economy that is strictly linked to an idea and a perception of the world. This vision is realised in a specific landscape that becomes a microcosm fruit of a cosmos-vision. An emphasis is placed on the water management traditional techniques and local knowledge considered as part of cultural history. Special attention is given to the Oasis Model described as a sustainable development alternative to the hydraulic civilisations model based on an abusive exploitation of water resources. The Oasis Landscape, interpreted as an appropriate water and ecosystem management, is proposed as an example for the realizations of sustainable projects in the arid zone and all round the world. The study of traditional knowledge is described as a contribution to developing a new water management paradigm more in line with the sustainable development approach and integration of technical, ethical and aesthetical aspects. Several examples of innovative use of ancient water management practices for agricultural, architectural and urban development purposes are described. Using traditional Knowledge does not mean directly reapplying the techniques from the past but understanding the logical reasoning underlying the knowledge system and reapplying it in a creative way: today's appropriate innovations constitute tomorrow's traditional knowledge.

KEYWORDS: water; Traditional Knowledge; oasis, ecosystem management.

POTENTIAL ENVIRONMENTAL IMPACT OF PURIFIED WASTE WATER ON THE GROUND AND THE CULTURES: CASE OF ALGERIA

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INTRODUCTION

In Algeria, the water shortage develops year by year, because of increase in the population, the industrial development and the rise of irrigated agriculture. The re-use of purified waste water (PWW) for the irrigation of the arable lands, can contribute to decrease this constraint. However, the irrigation by PWW could with time, to influence certain parameters of the grounds, such as salinity, biochemical and microbiological activities on the level of the rhizosphere. From this point of view, we undertook a study on agricultural plot irrigated by PWW, over several durations (2 years, 5 years, 11 years), of the area of Corso (Algeria).

MAIN RESULTS

On the level of the plots irrigated by PWW, the pH is slightly acid compared to the pilot plot. This acidity seems to be accentuated while going from the duration 5 years towards that 11 years. The Ca CO³ values are identical on the whole of the grounds and of the horizons, their low values reveal a no calcareous ground. The values of P₂O₅ have been relatively low in the two major horizons (H2 and H3) of the irrigated plot since 11 years compared to the two plots irrigated for 5 years and with the pilot plot. When with C/N, its rate in the major horizons (H2 and H3) of the irrigated plot since 11 years, has been lowest compared to that of the same horizons of the two plots irrigated for 5 years and with the pilot plot. The examination of the EC (Electric Conductivity) watch which the studied grounds have a low salinity. Thus, the measured EC does not reach the bar of 4 mmhos/cm; however one notices for the grounds of sites 1; 2 and 3 a light tendency of the increase in the EC in the H3 horizon (Fig. 1).

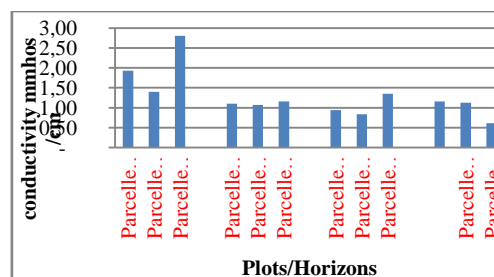


Figure 1. Effect of the irrigation by PWW on the salinity of the irrigated grounds (5 years; 11 years) and pilot

The density of the total germs recorded in the four grounds is identical (106 UFC/ml). The results show the absence of *Staphylococcus aureus* and *Salmonella sp.* Reducing Clostridium sulfito and Coliformes, one a population which decreases as the duration of irrigation by PWW increases. The dry matter rate of the ground has been appreciably higher in the two plots irrigated for 11 years and 6 years that in that irrigated for 2 years and the pilot plot.

CONCLUSION

We noted that PWW a salinity acceptable for the irrigation, however their use on medium term (11 years) showed an accumulation of salinity in the studied plots, especially in the major horizons. The results on the microflora of the ground of the pieces irrigated by PWW show that the total flora mésophile aerobic (TFMA) does not present variations according to the duration of irrigation. However, the density of the total colony count in the four grounds, remains less important than that reported for the grounds of the moderate areas.

Keywords: purified waste water; duration; salinity; micro flora; standards.

HYDROCHEMICAL CHARACTERIZATION OF THE GHRISS PLAIN AQUIFER USING MULTIVARIATE STATISTICAL ANALYSIS

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The Ghriss Plain is the most productive agricultural area in the west-northern part of Algeria. This semi-arid region is suffering from drought which has been affecting north western Algeria for the three last decades and an overexploitation of its water resources. The groundwater is the most used resource for the agricultural activities and for the supply water in the study area. However, the water-level drawdown of the Ghriss Plio-Quaternary aquifer towards alarming levels is causing major concern for the population of the area as well as for local and national authorities. The water table of the Ghriss Plio-Quaternary aquifer decreased drastically by more than 80 meters from 1970 to 2015 in some sectors. Groundwater chemistry is controlled by many natural processes as well as anthropogenic processes. The composition of groundwater depends not only on natural factors such as composition of precipitation, geological structure and mineralogy of the watersheds and aquifers, geological processes within the aquifer, but also on human activities, which can alter these fragile groundwater system, either by polluting them or by changing the hydrological cycle. The aim of this study is to investigate, using Statistical analysis, the origin of salinity and the major ions in the groundwater of the Ghriss Plio-Quaternary aquifer (northwest Algeria) and the understanding of its hydrodynamical and geochemical behaviours, in the context of natural and anthropogenic constraints. Samples from boreholes located in the study area were analyzed during the period 2001-2008. The Cl⁻ is the dominant anions and the Mg²⁺ is the dominant cation. In 2001 more than 70% of water samples are within the maximum permissible limit of Cl⁻ for potable water (250 mg/l). In 2008 and 2005 more than 56% of samples have a Cl⁻ concentration higher than this permissible limit. Nitrate concentrations are important and mean values ranged from 32 to 42 mg/l. Maximum concentrations are up to 180 mg/l, which is an indicator of anthropogenic pollution. Multivariate statistical techniques are widely used in environmental geochemistry. These statistical methods, capable of distinguishing complex relations among many variables, can be useful for source-identification problems. They are also used to examine phenomena associated with water quality and to understand the behavior and spatial patterns of water quality constituents. The statistical methods used are Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (CA). Correlation matrices show that a strong correlation exists among the major elements (Na⁺, Ca²⁺, Mg²⁺ and Cl⁻) and (EC and TDS). These relationships clearly identify the main elements contributing to the groundwater salinity and their tendency to follow a similar trend. The results of the two multivariate analysis methods reveal 3 important factors which influence the hydrochemical composition of groundwater. The first factor is a high salinity resulting essentially from the dissolution of evaporites (halite and gypsum), from the infiltration of runoff water and from the return to the aquifer of irrigation water. The second factor is an anthropogenic pollution of

rural origin, which affects the whole Ghriss plain to various extents. The high concentrations of nitrates, chlorides and potassium are its indicators. The third factor is the recharge of the Plio-Quaternary aquifer by the two other principal aquifers of the region, especially the Jurassic one.

KEYWORDS: groundwater quality; hydrochemical analysis; multivariate statistics; ghriss plain.

VULNERABILITY ASSESSMENT OF THE ALLUVIAL AQUIFER OF TEBESSA (NORTHEAST ALGERIA) BY THE DRASTIC METHOD FOR ITS PROTECTION

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Plain Tebessa has experienced in recent years a remarkable economic expansion, particularly agricultural, following the implementation of agricultural development programs namely the National Agriculture Development Program (NADP) in 2000 and the National Fund for the regulation of agricultural development (FNRDA) in 2001. This exposed the groundwater to pollution resulting from various agricultural activities.

Tebessa city is implanted in this plain; it has a population of 230328 inhabitants according to the last census of 2008. The volume of waste water discharged through the sewerage network (network unit) is estimated at 185 000 m³ / d in 2015. Unfortunately, the spill of the waste water, in nature, is without any treatment. This caused a groundwater contamination, so the study of the evolution of groundwater resources is therefore a major issue for people, biodiversity and evolution of terrestrial ecosystems in this region.

The purpose of this work is to study the possibilities of protecting this resource against anthropogenic pollution threats (agriculture, industrialization, urbanization ...), using mapping the intrinsic vulnerability. The evaluation of this vulnerability is achieved by applying the DRASTIC method, exploiting the functionalities offered by the GIS. The interpretation of the vulnerability map brought out 04 vulnerability classes (low, medium, high and very high). High class is the most dominant as it covers almost all of the aquifer. This requires the protection of this resource to save its quality in the medium and long-term. Such as hydraulic services do not have the means and tools to aid decision making that allow them to confront the risks to groundwater. So this card will serve as a tool to protect the groundwater.

KEYWORDS: Vulnerability assessment,; Tebessa aquifer; DRASTIC method; semi arid; Algeria

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WATER SCARCITY THREATENS EGYPT: DRIVING FORCES, IMPACTS AND CONTROL THROUGH MANAGEMENT PROGRAMS

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Variability, uncertainty and threat - three elements that form the processings and actions surrounding the globe nowadays and leaving science in a state of constant challenge. In Egypt, which is situated in the arid region, there is a tremendous increase in water demand resulting from the acceleration of population growth, industrialization, changes in standards of living, urbanization, and horizontal expansion of agricultural area. In addition, the threatening water quality resulted from pollution, increases the pressure on the country's limited water resources. Social factors (poverty, quality of life, unequal distribution of water and consumer's behavior), natural factors (climate changes), economic and political elements are main driving forces of water scarcity. Water scarcity is one of the major constraints to socio-economic development in the arid and semi-arid regions. Under this situation, water needs are being met at the expense of the ecological requirements. Increasing water scarcity will lead to intense competition for the resource across users sectors; therefore strategies for efficient allocation of the resources will become fundamental. Agricultural sector consumes more than 70% of available freshwater resources; therefore strategies for improving water use efficiency as well as water conservation and control of demand should be considered for facing water scarcity. Launching public awareness campaigns aimed at advocating a new water culture in a society based on the principle of conservation is a demand orientation measure that can be implemented. Optimum use of water resources is achieved through the reuse of wastewater (drainage and municipal) in agriculture and recycling industrial wastewater, sea as well as brackish water desalination, and rain harvesting are possible strategies for addressing water scarcity. Involving the private sector and cooperation with the Nile Basin countries is considered a must to increase the water use efficiency, control water demand and reduce the misuse of water. Cooperation with the riparian countries of the Nile Basin through the "Nile Basin Initiative Program" is planned implement projects to have additional inflow in Lake Nasser.

KEYWORDS: Egypt water resources, rational use of water, water stress, water scarcity, water management.

ANALYSE DE L'EFFET DU FONCTIONNEMENT HYDROLOGIQUE SUR LA VARIABILITE SPATIO- TEMPORELLE DES EXPORTATIONS DE SEDIMENTS PAR LE MODELE AGRO HYDROLOGIQUE SWAT DANS LE BASSIN VERSANT NAKHLA

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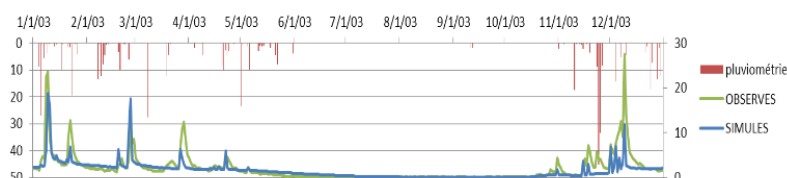
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Les ressources naturelles ; eau et sol ; sujettes d'une utilisation de plus en plus croissante et intense conjuguée à un contexte naturelle de plus en plus défavorable, sont soumises à une dégradation et détérioration qui touche aussi bien la qualité que la quantité. Afin de remédier à cette problématique, on propose d'évaluer leurs états, évolutions et interactions à travers le temps afin de conclure les meilleurs choix à appliquer pour une gestion rationnelle et durable. La méthodologie adoptée repose sur l'usage du système d'information géographique (SIG) dont l'aptitude à extraire, agréger et combiner l'ensemble des données spatio-temporelles, le rend incontournable pour la préparation des fichiers d'entrée et pour la visualisation des résultats. Combiné avec l'utilisation du modèle agro hydrologique SWAT (Soil and Water Assessment Tool) pour des opérations d'analyse et de modélisation du cycle hydrologique et des processus d'érosion et de déposition.

Le modèle SWAT 2009 (Soil and Water Assessment Tool) est mis en œuvre à un pas de temps journalier ; au niveau du bassin versant Nakhla situé à 20 kilomètres au sud de la ville de Tétouan ; Suites à une structuration préalable des données spatiales (pluviométrie, température, sols, couverts végétaux, topographie et discrétisation en sous-bassins) à une résolution spatiale et sémantique adaptée aux objectifs de la modélisation et à la disponibilité des données. La procédure de calage appliquée est basée sur l'utilisation d'une longue série climatique allant de 1980 à 2010 répartie entre la phase d'initialisation, phase de calage et la phase de validation en combinant l'outil Arc Swat et SWAT Cup.

Les résultats obtenus après calage présentent un taux de réalisme satisfaisant dans la représentation des interactions entre les différents compartiments du modèle, et la simulation des débits, dans un premier lieu pour le calage mensuel (NS=0.714, $R^2 = 0.83$) et le calage journalier (NS= 0.60, $R^2= 0.65$) et dans un deuxième lieu pour la validation (NS= 0.70, $R^2=0.80$).



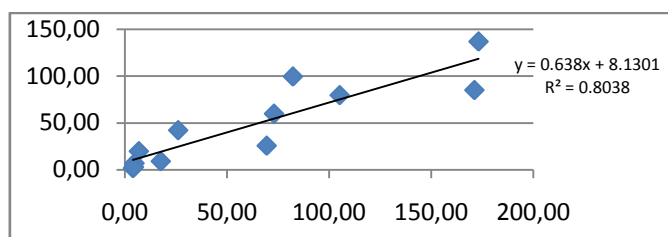


Figure 2: comparaison des débits observés et simulés par le modèle SWAT

Les résultats de la répartition spatiale et la quantification des taux de sédiments produits par le processus de l'érosion à travers le bassin, sont validés grâce à la comparaison avec des mesures discontinues des sédiments réalisées au niveau de la station Timezouk présente au niveau du bassin aussi grâce à l'utilisation des résultats de la bathymétrie effectuée au niveau du barrage Nakhla.

L'étude de la relation entre la variation des caractéristiques climatiques et hydrologiques qu'a connue le bassin au cours de la période étudiée a permis d'expliquer une partie importante des variations en matière de production des sédiments. Cependant le phénomène étudié est sujet de plusieurs interactions des différents acteurs du milieu naturel (topographie, géologie, climat...); parmi lesquelles l'occupation ou l'utilisation des sols dont l'impact doit être pris en considération afin de reproduire l'image la plus réaliste des phénomènes ayant lieu à travers l'espace et à travers le temps au niveau du bassin versant étudié.

Mots clés : SWAT, hydrologie, érosion, Nakhla, Maroc

THE REUSE OF NON CONVENTIONAL WATER IN ALGERIA: A SOURCE OF STRUGGLE AGAINST CLIMATIC CHANGES

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INTRODUCTION

Drought is being an unavoidable fact to Algerian climate, this is becoming a permanent and inexorable fact on a large part of the country that is why, and the climatic variability has to be considered in the economic planning as the deficit years are persisting, disorganizing development plans. According to [1] Algeria has a global mobilizable hydraulic potential that does not exceed 13.2 billion cum of water, leading to an annual volume of 412 cum to each citizen considering all uses. This theoretical number is indicating a situation of severe water scarcity

obstructing all the country's development and confirms that Algeria is widely affected by hydric stress among the category of the poorest countries regarding hydric potentiality, that is to say that it is beneath theoretical limit of scarcity fixed by the World Bank i.e. 1000 cum/inhabitant/year.

The agricultural sector is the most exposed sector of activity to climate variability considering the vital role it holds in this sector within the realization of objectives of food safety of the country in order to improve or at least stabilize the national production to an acceptable level, particularly the one of strategic cultures; and given that 76% of the SAU are located in disadvantageous climatic zones where water represents a major issue and an obstructing factor in agricultural production.

MAIN RESULTS

The strategy of struggle and adaptation to climatic changes consists in programs aiming for realizing the objectives of the national politic of water : This politic of development aims for two main goals:

- Securing the supply of potable water of populations ;
- Enhancement of food saftey rates by the offered possibilities au maintenance and the extension of irrigated areas.

The strategy that allows to ensure the necessary water resources, relies on a wide reuse of purified wastewater benefiting the irrigation and the industry and the adjustment of the deficit of the coastal zone by seawater desalination and water saving.

The purified waste water reuse for irrigation constitutes then a new integrated approach in the planification and water resources managment and particularly in the lacking countries.

It allows to release the pure water resources for potable and industrial water procurment; The economy of the conventional resource and for brining a postive environmental impact and improve the agricultural outputs. It also allows the mobilization of a potential resource and the protection of the receiving environments (Oueds, Littorals, lakes...)

The volume of released wastewater to the national scale is currently estimated to almost 750 milions cum and to exceed 1,5 bilion cum by 2020. In order to take in charge the purification of this waste water potential, The water resources sector has set up a hopeful program regarding the realization of purification plants. The total installed capacity after achieving this program would be about 1000 milions cum/year of purified waste water, that is to say the equivalent of 10 dams having an average capacity.

For an irrigated surface of 2 million ha by the end of 2019 and a development of water saving on 1 million ha and for an average dose of 6000 cum/ha/year, this evolution will require a theoretical volume of 12 billions to explore and this, from both conventional and non conventional water resources.

Furthermore, Algeria, through the desalination of sea water, has begun by desalination projects, with an objective of 2.3 million cum/day by 2016 and a large desalination plant receiving a flow of 500000 cum/day.

In this conference, we are going to discuss:

- ✓ The current state of water resources, the future issues and challenges.
- ✓ Climatic changes, flooding, drought.
- ✓ Desalination of seawater; an unavoidable back up?
- ✓ Waste water treatment and reuse possibilities
- ✓ Integrated management and good governance:

Suggestions of new strategies regarding sustainable development are going to be established by 2050.

KEYWORDS: Water Resources, Climatic changes, Desalination; Integrated management; good governance

STUDY AND PHYSICO-CHEMICAL CHARACTERIZATION OF WATERS OF OUED SAKIA ELHAMRA (MOROCCO)

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In a context of scarcity, fragility, and unequal distribution of the water resources in the south of Morocco, Oued Essakia Elhamra underwent and continues to undergo discharges of raw domestic wastewaters of the town of Laayoune. In order to characterize and quantify the impact of domestic warm water on this river, several physicochemical parameters were the subject of a spatiotemporal monitoring during 2015.

The result of physicochemical analyzes shows that the waters of the dam Essakia Elhamra are of acceptable quality subject to the evaporation effects, the salinity of the water increases, however, the waters in the runoff area of existing sources in the bed of Oued Essakia Elhamra have mineralization well beyond the standards as indicated by the excessively high values of electrical conductivity that reach up to 163 ms / cm. These waters have a high pollution confirmed by the high values of BOD5 (117mg / l), COD (443mg / l), the total phosphorus (2.6mg / l) and ammonia nitrogen (123mg / l). The waters of Oued Essaquia Elhamra with a high salt load in the trickling spring area are mixed with wastewaters in the spreading area of the city of Laayoune, this significantly reduces the biodegradability of these. Regarding trace elements (Cd, Pb, Cu, Fe and Zn), analysis of the results shows that the concentrations of heavy metals in the waters of the dam Essakia Elhamra do not present a risk to the superficial aquifer of Laayoune and Fem Elwad On the other hand the waters show very high concentrations in the area of wastewater spreading of the city of laayoune and trickling spring waters that constitute a real threat to the superficial aquifer of Fem Elwad

KEYWORDS: Oued Essakia El Hamra, waste water; salinity; heavy metals, organic pollution

RELATIONSHIPS AMONG LAND COVER, SOIL TEXTURE, SOIL CARBON AND SOIL ERODIBILITY IN A SEMI-ARID AREA (WESTERN HIGH ATLAS, MOROCCO)

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To satisfy water demand estimated at 16.77 billion m³ in 2020 (Morocco embarked since 1960 on an ambitious program to increase the number of dams to boost water retention capacity. This national strategy of implementation of dams helps not only to ensure water supply but also to fight against floods and to produce energy. However, the loss of storage capacity of dam reservoirs by sedimentation is estimated at 75 million m³/year.

Understanding the mechanisms behind soil properties is important for developing more accurate predictions of soil loss in different land covers and estimates the dam sedimentation, which can be incorporated into improved climate–erosion models and used to better understand the ecosystem services of agricultural land-scapes.

To enhance the understanding of the spatial variability of land degradation and its dominant influencing factors in a mountainous region such as N'fis Watershed located in Western High Atlas of MOROCCO, we collected data from the available soil maps, examined whether land use types (farmland, grassland, forestland and croplands), topographic conditions (elevation, slope and CTI) and vegetation coverage (NDVI) affect the spatial distribution and content of Land degradation. The results indicated that, soil erosion decreased among different land use types in the following order: forestland, Scrubland, grassland, farmland an accurate spatial prediction of soil erosion content has great significance north of the watershed. This study exhibited that the combined use of vegetation index and terrain attributes would result in a suitable method of predicting soil erosion distribution even in complex terrain.

To validate the model applied, we used the result obtained from Sediment yield data derived from sediment volume estimations from comparing bathymetric surveys of the N'fis reservoir, Sediment yield data were derived from sediment volume estimations that resulted from comparing bathymetric surveys of the N'fis reservoir (the Tasekourt dam). According to ABHT (Agence du BassinHydraulique de Tensift), total reservoir sedimentation between 2008 and 2012 amounted to 2.84 Mm³, with a calculated annual sediment yield of about 0.71 Mm³, assuming a linear temporal distribution. The annual average of the area-specific sediment yield derived from the dam sediments totals 3.59 t ha⁻¹ yr⁻¹ for the whole drainage basin area, it is inferred that the model used predicted sediment yield value (5.43 t ha⁻¹ yr⁻¹) is significantly greater than the sediment yield values derived from volume change calculations of the dam deposits.

Keywords: Dam, Modelization, Semi-arid area, soil erosion

STUDY OF THE POPULATIONS OF MACROINVERTEBRATES FAMILIES FOR THE AFENOURIR'S LAKE

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Introduction

Benthic macroinvertebrates (MIB) are animals visible to the naked eye bodies, present and abundant in all ecosystems, particularly wetlands. MIB play an important role in the aquatic food chain, since they are the main food source for many fish, insects and amphibians. They must be present in sufficient quantity and with a significant diversity to maintain the ecosystem of the wetlands in balance, functional and healthy. The MIB are relatively sedentary, which makes them good witnesses of local conditions because they include a large number of taxa, many of which have a degree of tolerance known, reflecting significantly different sources of pollution and degradation wetlands. The objective of this study is to assess the state of the water quality of Lake Afenourir classified "Ramsar Site" since June 1990 and consequently the degradation of the ecosystem, for identification quantitative and qualitative benthic macroinvertebrate's existing at this wetland.

Results

To carry out this study; four stations were selected at the lake, taking into account certain criteria: the direction of flow, accessibility, pollution sources, etc. The analysis of all of benthic fauna collected during this study period, shows that the crustaceans are the most digitally recorded and represents the highest percentage at the lake Afenourir (47%) followed by Diptera (31 %), annelids (11%) and the Ephemeroptera, the lowest group (2%). A total number of individuals/m² of 2198 corresponding to 20 families in four faunal groups. We have chosen to make an abundance of fauna polluo-tolerant group (Chironomidae, annelids) and polluo-sensitive (Ephemeroptera), to make a comparison between them, with the aim of assessing the biological quality of the lake. This abundance fluctuates stations, varies between 218 and 279 individuals for polluo-tolerant and 2 to 15 for polluo-sensitive. (Fig. 1).

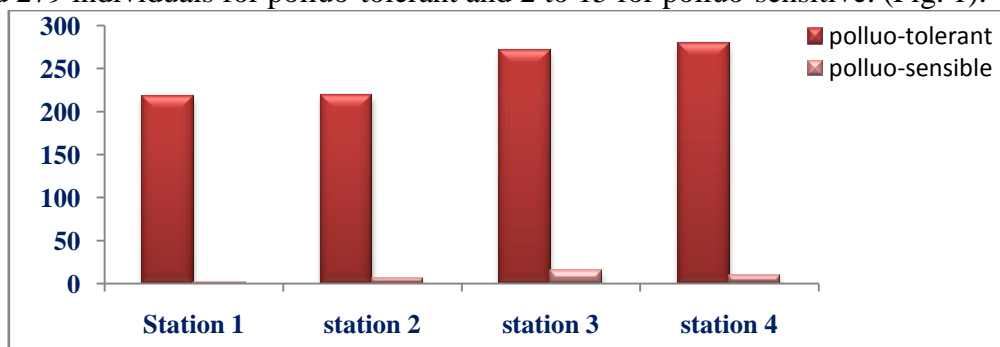


Fig. 1: distribution of tolerant and sensitive faunal groups per station

Conclusion

The Afenourir's Lake is located in the Moroccan Middle Atlas Central; it is a mountain site shallow less than two meters. The lake lies within the perimeter of the National Park of Ifrane and ranked RAMSAR. The fauna inventory made in the presented study is an important first database. The fauna studied is characterized by a variable taxonomic diversity depending on the degree of water pollution of Afenourir's Lake. The condition and water quality of the Lake is dependent on environmental conditions at each station, as well as the influence of human activities.

Keywords: Afenourir Lake, Benthic Macroinvertebrates, Quality, Fauna.

FIRST MONITORING AND ECOLOGICAL MODELING IN AN URBAN DRINKING WATER SUPPLY SIDI ABDERRAHMAN (SAFI, MOROCCO)

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The water quality of freshwater systems is controlled by climatic variability, hydrological, biogeochemical, and anthropogenic factors [1]. Dam Sidi Abderrahman (Safi-Morocco) it's actually the only official source of freshwater in the Safi city area. With the shortage of water, changes in rainfall patterns, and its particle location (in extreme downstream on Oum Rbii basin), it seems necessary to propose a seasonal and an inter-annual monitoring in order to predict the spatial and temporal distribution for some water quality characteristics (physical-chemical, nutrients, chlorophyll-*a*, and phytoplankton), major key indicators of biogeochemical processes changes on water ecosystem. Our monitoring was taken fortnightly between May 2011 and December 2013. Campaign results have suggested the homogeneity of the water column and classified the dam as a warm polymictic, oligotrophic lake with turbid character. Analysis of phytoplankton spectrum reveals the presence of 65 phytoplankton taxa (25 Diatoma, 16 Chlorophyceae, 9 Cyanophyceae, 2 Euglenophyceae and 1 Dinophyceae). No Blooms were detected. The phytoplankton community is correlated with the biotic and abiotic factors of the lake. Monitoring results were taken to develop a first ecological model in the water column of the Sidi Abderrahman Dam. This model will be able to detect the significant key characteristics of the temporal and spatial distribution of nutrients and phytoplankton community. Those keys may have eventually, an impact in organization of ecological and biogeochemical functioning on the lake.

KEYWORDS: monitoring; sidi abderrahman; modeling; phytoplankton; nutrients.

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REFERENCES:

[1] Delpla I, Jung A V, Baures E, Clement M, Thomas O, 2009.. Environment International, 35: 1225-1233.

**EVALUATION OF CEMANEIGE-GR4J MODEL USED TO SIMULATE
STREAMFLOW IN THE RHERAYA CATCHMENT (HIGH ATLAS, MOROCCO)**

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The Haouz basin, located in the Central Morocco, is composed of two parts: the Haouz plain which contains the Marrakech city in the north and the High-Atlas mountains culminating at 4165 m in the South. The plain, covering a surface of 6000 km², has a semi-arid climate characterized by low rainfall (~250 mm/year) and high evaporative demand (~1400 mm/year). The High-Atlas mountains receive more important precipitation either as rain or snow falls and encompasses the drainage basins of several intermittent streamflows (wadis) that cross the plain from south to north. Therefore within the Haouz basin the water resources have two main components: the wadis fed by mountains rain and snow fall and groundwater contained in the alluvial deposits of the plain. The mountains, constituted mainly by impermeable material, generate flush floods. When reaching the piedmont alluvial plain, the more important ones flow onto their floodplains and are partially derived for traditional irrigation. The seepage losses in this area might be an important source of groundwater. The present study aims to evaluate the conceptual model (CemaNeige-GR4J) by applying it on a time series from 1989 to 2009. This model allowed us to:

- Conceptual modeling of the wadi's flows at a daily basis;
- Calculate the Snow Water Equivalent (SWE) at the Rheraya catchment;
- Calculate the percentage of catchment covered with snow;
- To assess the robustness of the conceptual models in semi-arid areas.

Keywords: Hydrology, CemaNeige-GR4J, Rheraya, conceptual model.

CONTRIBUTION OF SIMULATION AND GEOGRAPHIC INFORMATION SYSTEMS IN THE SPATIALIZATION RISK OF FLOODING IN THE WATERSHED OF WADIRHERAYA (HIGH ATLAS, MOROCCO)

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INTRODUCTION

The watershed of WadiRheraya is located on the northern flank of the High Atlas of Morocco. It is characterized by a branched hydrographic system, low permeable bedrock, discontinuous plant cover and steep slopes. It is exposed to ocean disrupted flows from the North and Northwest directions. These morphological and climatic conditions favor a significant rainfall and torrential flows with powerful flood of short duration.

MAIN RESULTS

The aim of this study is to calculate the frequency analysis of maximum daily flow over a time series of 38 year recorded at the Tahanaout station, which will allow having a probabilistic concept of the periodic appearance of floods, associated with peak flows.

The study is based on two main axes:

- Presetting of extreme flows according to a probability law selected from a diversity of laws [1], where the parameters are identified by the likelihood method minimizing the differences between the observed rates and predetermined rates. The choice of the most suitable law for the adjustment of the flow distribution will be confirmed graphically and then numerically using statistical criteria.
- The flood extent spatialization associated with predetermined rates using the computer tool HEC-RAS (Hydrologic Engineering Center–River Analysis System) developed by the US Army Corps of Engineers [2].
- The visual adjustment results using Akaike information criterion (AIC) and Bayesian information criterion (BIC; also called Schwarz Bayesian criterion, or SBC) allowed making the choice of the most appropriate law: The most appropriate law to the predetermination of extreme flow of Rheraya watershed is the Log normal law (Table 1). Several studies have rightly affirmed that the best fit for arid and semi-arid hydrological regimes is obtained by log normal law [3]. The estimates laws were programmed using the R software.

PR	Probabilité	L.Normal
1000	0.001	636.56499
500	0.002	517.18521
100	0.01	301.26712
50	0.02	230.68082
20	0.05	154.5619
10	0.1	108.28913
5	0.2	70.38437
2	0.5	30.869

Table 1: Estimation of flows associated with a given return period according to the Log-Normal law

Using GIS software, we simulated the extent of decades and centuries flooding of the wadi. The mapping of flood areas illustrates the extension of river overflows over the banks of river Rheraya, especially the floodability of cultivated fields, some buildings and the road which crosses the basin towards the city of Marrakech (Figure 1).

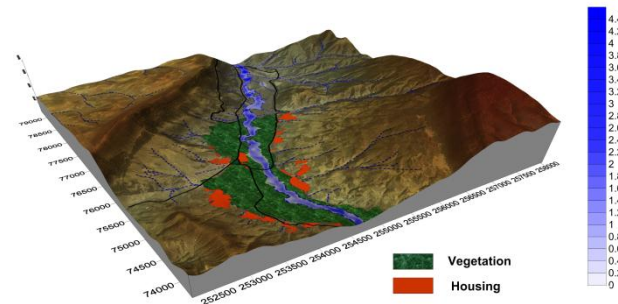


Figure1: Simulation and spatialization of the centennial flood of Rheraya

This work reveals the flooding risk of in areas characterized by human activities and calls all players in field of hydrology to manage this risk through prevention and prediction.

REFERENCES

[1] Meylan P. Favre, A.C. et Musy A., Hydrologie fréquentielle. Unescience prédictive. Presses polytechniques et universitaires romandes, Lausanne, 2008, 184 p.
 [2]US Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System, user’s manual, 2010, 790 p.
 [3] Ubreuil P., Introduction à l'analyse hydrologique, Ed. Masson-ORSTOM, Paris, 1974 216 p.

LONG AND MEDIUM-TERM EVOLUTION OF A SEMI SHELTERED BEACH (BAY OF AGADIR, MOROCCO-ATLANTIC OCEAN)

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INTRODUCTION

The coastal zone is one of the most dynamic areas of the earth's that fluctuates in a variety of time scales. This behaviour introduces many difficulties when reconstructing long-term coastal trends [1-2]. The current work presents the results of a combined study on the long and medium-term evolution of the bay of Agadir (Atlantic ocean –Morocco). It is an interesting sector showing a variety of coastal environments greatly affected by natural climate change and human structures.

In this study, medium-term variations have been monitored with a monthly periodicity during a period of 2 years through cross shore profiles. The analysis of long-term variations for a period of 26 years was carried out using several digital elevation models. To link the morphological changes with the hydrodynamic regime, we conducted a simulation of wave propagation from offshore to the coast, and calculated currents generated by breaking waves and the rate of non-cohesive sediment transport. Detailed investigations were taken up to analyse the volumetric and morphologic variations of the intertidal zone in both time scales, long and medium term.

MAIN RESULTS

The obtained data was representative of both seasonal and annual variations. Over long-term, the northernmost of the Agadir bay recorded accretion, while recession has been recorded in the southern part. Over the medium-term time frame, the same tendency of coastal erosion and accretion was recorded. In the north the morphology clearly states dissipative conditions with the formation of an intertidal bar during low energy period. Such bar plays an important role in the stability of the beach as they can absorb storm waves and dissipate their energy. The morphology of the south portion of the bay clearly states reflective conditions with a steep slope. The partial convergence between the long and the medium-term trends shows that the seasonal variability still remains influenced by long term mode of variability; namely a northern sector in slight accretion and a southern sector in recession (Figure 1).

In addition to the wave energy condition and the nature of gradient that is attenuated from north to south, slope of the beach along with littoral and rip currents are responsible for the observed erosion in the south (Figure 1). In the early of 1980s this portion of the bay was characterized by developing foredunes 12 to 14 m high. The destruction of the foredunes in the early 90 has accentuated the crucial situation in the south.

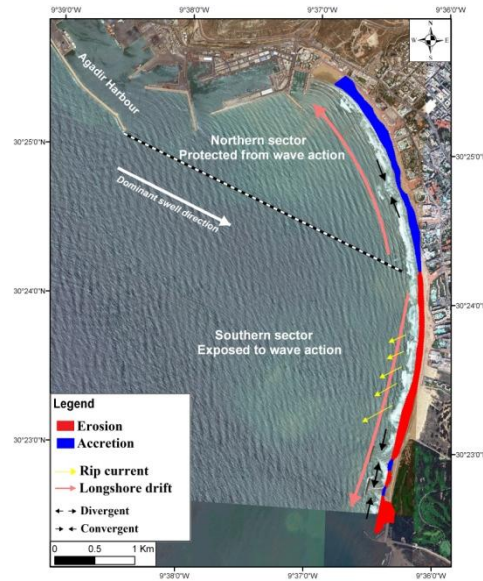


Figure 1: Synthesis of shoreline changes between 1975-2011, hydrodynamic behavior and sediment cell and sub cell exchange in Agadir Bay

In this study we have used a combined approach addressing multi-decadal shoreline displacement, very-high resolution beach topographic surveys, and hydrodynamic modelling in order to characterize coastal sand transport pathways, the sediment budget, and patterns of evolution displayed by the embayed shoreline of Agadir under the influence of strong economic development pressures. Our results show that erosion is continuing to affect an increasingly longer stretch of bay shoreline that was hitherto relatively stable. These results also show that the negative sediment budget may essentially reflect blocking of alongshore sand transport resulting from impingement of Agadir harbour on the shoreface well beyond the depth of wave closure, and anthropogenic sand extraction for development purposes that has led to irreversible dune destruction. These changes may generate further shoreline instability in the decades to come that will likely be aggravated by sea-level rise.

REFERENCES

- [1] Crowell, M., Leatherman, S., Buckley, M.K., 1991. Historical shoreline change: error analysis and mapping accuracy. *J. Coast. Res.* 7, 839–852.
- [2] Anthony, E.J., Vanhée, S., Ruz, M.H., 2006. Short-term beach-dune sand budgets on the North Sea coast of France: sand supply from shoreface to dunes and the role of wind and fetch. *Geomorphology* 81, 316–329.

ESTIMATION OF GROUNDWATER VULNERABILITY AND THE IMPACT OF THE ANTHROPOGENIC ACTIVITIES ON THE KARST SYSTEMS OF SAÏDA MOUNTAINS

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Groundwater from karst aquifers of Saïda's mountains represent an important resources for water supply; both for the local population and agriculture, also for the economic, industrial and touristic development. Understanding the behavior of karst aquifers (hydrodynamic and hydrochemistry), as well as the charging, discharging and circulation processes, that have such a crucial importance for the development of effective water management. Karst systems studies are aiming to characterize the origin of the underground streams, and to quantitatively and qualitatively assess the resources, finally to estimate the vulnerability of these aquifers to anthropogenic contamination. Karst is a middle that has little protective soil surface, so many fractures and openings in heterogeneous dimensions and orientations, besides the charging options while the diffusion by infiltration that has a direct runoff, altogether is giving this environment a large vulnerability to pollution. To speak about karst aquifers pollutants can both spread rapidly to an outlet source (fast flow in the karst system) and remain stored for a longtime in the micro-cracks, also in cavities and areas of slow flow of the enclosing carbonate formation. All these features give the karst systems an increased vulnerability towards all kinds of contaminants (chemical, biological or physical), especially in the areas with high anthropogenic activity. The risk assessment is a step in the groundwater resource protection processes, particularly the establishment of protection perimeters. On the research plan, the work will be the application of different methods, which are based on different concepts applied in the karst systems field that is: DRASTIC, COP method, Kfactor, EPIK method, VURAAS, ULK, RISK, PaPRIKA. A synthesis and further comparison of these methods will allow to choose the suitable one in the context of the area study. The obtained results will be a concert tool in the managers of water resources hands, in order to undertake a specific measure to protect the areas that are most exposed to contamination for the quality preservation of this vital resource.

KEYWORDS: VULNERABILITY; KARST AQUIFERS; HYDROCHEMISTRY; PROTECTION PERIMETER; SAÏDA MOUNTAINS.

DROUGHT AND FLOOD, EXAMPLE OF TLEMCCEN CITY (NORTH-WEST OF ALGERIA)

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In the last years, Tlemcen city underwent floods repeatedly. The last ones were respectively at the 19 October 2007, 24 October 2008 and then 13 November 2012. These floods caused big damages, the roads awash, some neighborhoods were isolated and the city paralyzed, rescue services have had to intervene repeatedly in emergencies. Many people consider the repetition of these events as consequences of climate changes.

In this paper, we show that the climate change is not the principal reason of these events, but these floods are the results of combined effects of several factors where the climate change is only one among other.

Indeed, statistical tests (Pettit, Hubert segmentation) applied to several rainfall series in the region [1, 2] have shown that the region has experienced a decrease in rainfall since the 1974/1975 years and that the rainfall is more favorable between 2007/2008 and 2009/2010 (We do not have data after this date). Floods were indeed observed after 2007/2008, during the rain return period [3], however, we show that the principal reason of floods is not only due to the rain return after long drought period, but also to uncontrolled urbanization and topography of the city.

In fact, Tlemcen city has been expanded since 1970. This development was mainly to the north and west of the town. The south side is blocked by the mountains and the east has a broken relief. Unfortunately, some urban sprawl was in unfavorable terrain for construction; in beds of wadis which were dried up after the 1974/1975 years. Then the rain return has revived these small streams built. To this anarchic urban sprawl, the topography ideal to runoff is added. Tlemcen is built on the side of a mountain. It has an overall slope towards South-North. This topography is not uniform; there is steep slopes in the South; around 20%, and between 1% and 3 % in the center with a strong value between 5% and 15% in the north.

In conclusion, the floods regularly seen in Tlemcen city are much more due to human intervention than to natural factors.

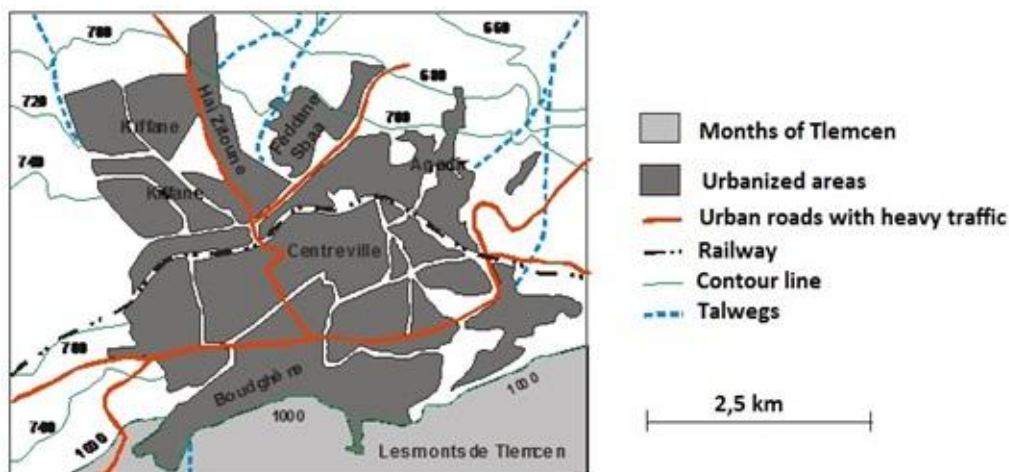


Figure 1: Topography and hydrography of Tlemcen city.

KEYWORDS: Tlemcen, drought, flood, topography, urbanisation.

References

- [6] Lubes-Niel H., Masson J.M., Paturol J.E., Servat E., Revue Sciences de l'Eau, N°3, 1998, p. 383-408.
- [7] Logiciel Khronostat, <http://www.hydrosciences.org/>
- [8] Nouaceur Z., Annals of Valahia University of Targoviste, Geographical series, Tome 11, 2011.

PERFORMANCE DIAGNOSTIC AND AGRICULTURAL PROFITABILITY OF THE WWTP OF KOLEA-TIPAZA (ALGERIAN COAST)

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INTRODUCTION

Water Resources Management is one of the main axes of preoccupation of Algeria to follow the path of Sustainable Prosperity. There are Many Acting institutions specialized in sanitation and treatment plants management that contribute to water resources depollution. Besides, Algeria is paying more and more attention to the profitability of purified water and its reuse possibilities. In this project, we spotted the WWTP located in KOLEA to make a whole diagnostic leading to detect process issues and coming up with enhancements recommendations.

After the characterization of the purified water and other by-products and the assessment of treatment performance, we A discuss the possibility of reuse in agriculture in order to take advantage of this plant both economically and environmentally.

Our WWTP is located in KOLEA. Since 1986, the plant receives and purifies wastewater by Activated sludge process and prolonged aeration in order to remove both the carbonaceous and Nitrogenous pollution.

The region of KOLEA is sanitized through a WWTP of two compartments: The first one is old and designed for 50 000 inhabitants, with an average flow of 7310 cum/day, and the second one is an extension which is meant to assume the purification for the projected population until 2020; that is to say for 75000 inhabitants with an average flow of 3600 cum/day.

MAIN RESULTS

First, The Laboratory results of wastewater and by-products parameters evolution from June 2010 to March 2011(functional period) have been statistically summarized and illustrated into graphics and used for ratios calculus. The interpretation of the gathered data has allowed us to make a meticulous assessment of: the treatment performance, the conventional tolerability for release in nature or agricultural reuse and finally the energetic output of the plant.

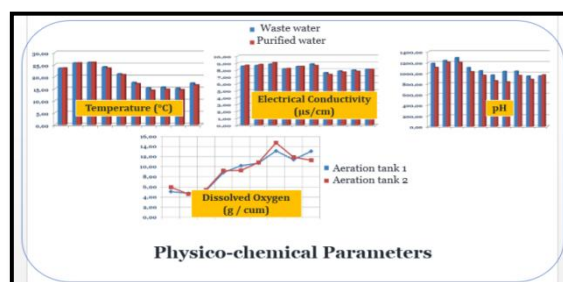


Fig.1. Evolution of Physicochemical Parameters

Physicochemical parameters respect all the regulations for both irrigation and release; except for the high amounts of dissolved Oxygen that lead to sharp excess in energy consumption and the concentration of Na⁺ ions which exceeds the conventional value for the irrigation for sensitive agricultural areas.

The plant provides a good elimination of SS^[1], BOD^[2] and COD^[3]. Besides, the Nitrogen and Phosphorus elimination remains acceptable as long as the environment of release is not sensitive to Eutrophication.

The Mud does not present a problem of toxicity but the lack of stabilization still can provoke temporary Nitrogen congestion. So, it is highly recommended to transport the mud during agricultural growth.

Unfortunately, there were still many important measurements that could not be provided such as: mineral Salts, regular quantification of heavy metals, water alkalinity (Carbonates and Bicarbonates), a biological quantification of pathogen microorganisms.

CONCLUSION

Based on all the deductions above, the plant can be both economically, environmentally and agriculturally rewarding but still needs many enhancements to function as a Healthy organ of the environment.

KEYWORDS: waste water treatment plant, KOLEA, diagnostic, valorization.

Acknowledgement

This study is included in the activities of the Research Laboratory of Water Sciences (LRS-EAU) of the National Polytechnic School (NPS) managed by Pr Ahmed KETTAB within the IRRIGATIO ERANETMED Project. We would really like to thank warmly its Coordinator Pr Massimo DEL BUBBA as well as our partners, the team leaders: Pr. *Maria C BRUZZONITI*; Pr. Naaila OUAZZANI, Dr Nesrine BOUJELBEN, Pr Emad Al-Karablieh; Pr. Laila Mandi for their deployed and consented efforts to succeed at this project.

STRATEGY OF ADAPTATION OF THE WATER RESOURCES IN THE HYDRAULIC BASIN OF OUM ER RBIA TO THE CLIMATE CHANGE

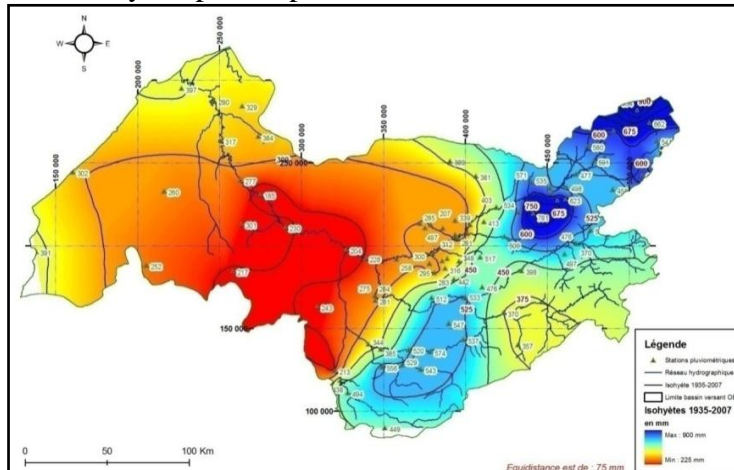
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The Hydraulic Basin of OumErRbia was the first basin on the level of installations. This basin is also characterized by its solidarity with the other hydraulic zones and that is found on the level of the transversewater it ensures towards the center and the south of Morocco since years.

The Hydraulic Basin of OumErRbia already currently knows a hydrous deficit. The strong reduction noted in the contributions water for the years 1980-2010 (of the order of 40% compared to the years 1940-1980) and increase in demand and the water scour by various forms of rejections explains this situation. The forecasts concerning the climate change in this area go in the direction D` an increase in the warming of the area by 2030 with the increase in the losses evaporation and by evapotranspiration that induces.



The level of precipitations must according to these forecasts stagnate or decrease slightly compared to the current situation. Also, the scarcity of water, which characterizes this area and the recurring droughts, will be part of the hydro-climatic landscape of the area for the 20 years to come.

The strategy adaptation of the management of the water resources of the area the climate change includes programs saving in water, of water mobilization. It acts as large many actions going in the direction of an adaptation to the expected effects of the climate change.

But to limit adaptation of the policy of the management of water of the zone to these programs would be insufficient. It seems necessary to carry out the actualization of the strategy of in

there integral in a more explicit way the climate change risk so much to the level of the vision and of the assessment/request for 2030 offers to the level as of actions having to be carried out.

Work carried out made it possible to define objective in front of being aimed by a strategy of adaptation of the management of the water resources in the Hydraulic Basin of OumErRbia and several basic principles having to guide the strategic choices having to be made.

This work showed that the taking into account of the climate change risk for the area must lead us to act in two directions on the level of the planning of the management of water of the zone during the decades to come

Let us note that this strategy of adaptation aims above all the installation of an iterative process of follow-up and update of the climate risk/water for this area and its integration to the fur at measure to the policies of water projected. It is thus essential that the structures of governance of these aspects suggested are installation as soon as possible.

KEYWORDS: Climate change, measurements of adaptation, Integrated Management, Resources Water, Strategy of adaptation....

FREEZING SEPARATION TECHNOLOGY FOR HYBRID SEAWATER DESALINATION INDUSTRY

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INTRODUCTION

The lack of potable water is still a problem in many countries. This is due to population growth, change in lifestyle, water pollution, inefficient use of water, and climatic changes. Considering the nearly endless water resource in the oceans, seawater desalination is an increasingly attractive solution. Effectively, more than 17,000 desalination plants are in operation in 150 countries worldwide. The capacity will reach 126million m³/d by 2016, up from 76 million in 2010.

Seawater desalination processes are a large energy consuming. Using fossil fuels, these processes implementation is compromised by an important environmental impact. Actually, many technological advances and innovations are trying to improve industrial seawater desalination processes; essentially, to reduce the process energy consumption as well as environmental impact, and to improve the desalinated water quality. Despite all this progress, seawater desalination technologies are still imperfect, costly and largely inefficient. Thus, development of new and sustainable processes is among the most significant challenges.

In this context, this paper explores the freezing separation process for seawater desalination purposes. This process consists of water removal from seawater by freezing it until ice crystals are formed and separated from brine. It allows obtained high purity water with high efficiency and low energy requirement. In the past, the combination of lacking equipment and prejudices (“cooling is always too expensive” and “the crystals will never be pure”) has hampered development and implementation of freeze desalination process. However, these caveats have become recently less important. This has resulted firstly of the freezing separation technologies development to a greater extent in several industries and secondly of the growing attention to exploring more effective solutions to potable water shortage that is being actually a very critical problem in more and more regions worldwide.

The objectives of the present work are to discuss recent developments and innovations occurring in this freezing separation process and to review and analyze the main methods currently being investigated in this process, especially for seawater desalination. Moreover, the possibility to use hybrid process, currently having significant profits, will be discussed in order to propose and develop a new innovative system.

MAIN RESULTS

Most recent freezing separation technology by crystallization of water as ice is widely used in many different industrial sectors; especially food and chemical processing. Thus, this technology has been developed to a greater extent and several industrial plants are currently available. Effectively, freezing separation technologies present many advantages. The main ones are the less energy requirement than other processes such as distillation and also the little potential of scaling and corrosion due to the low operating temperatures. Three important applications seem to be profiting from freezing separation process favors: concentrating fruit juices, purifying organic chemicals, and treating hazardous wastes. Although different

researchers have currently investigated a variety of freezing separation technologies for seawater desalination, the optimum technique for freezing and separation ice is neither enough known nor well controlled. Indeed, it is almost impossible to obtain pure ice crystals by one freezing cycle. Factors influencing ice quality during this freezing process are not well mastered. Highly saline water trapped in the ice crystals, which means that obtained seawater ice although purer than seawater, cannot be considered as pure fresh water.

Otherwise, hybrid technologies currently know a growing attention in industry. Moreover, it has been shown that freezing separation technology seems to be very successful when employing hybrid process that combines freezing process and other seawater desalination technologies such as reverse osmosis (RO). Thus, we proposed in this study this freezing process as seawater pretreatment upstream RO module. Effectively, the proposed freezing pretreatment process presents several advantages, such as relatively pure feed solution into the RO module compared to conventional and membranes pretreatment processes. This means less fouling and lowers operating pressure in RO plant. Therefore, costs of both high-pressure pump and membrane can be reduced, and high-quality of produced water can be obtained.

As a conclusion of this synthesis and discussion, we proposed a new innovative hybrid process that is consisting in combining freezing technology upstream reverse osmosis (RO) module for seawater desalination. Moreover, in order to more reduce energy requirement and take into account environmental impact, coupling solar thermal energy with the proposed hybrid seawater desalination process can also be explored.

KEYWORDS: freezing; seawater; desalination; hybrid, pretreatment

SUSTAINABLE MANAGEMENT OF WATER RESOURCES IN MOROCCO: CASE OF IRRIGATION WATER IN THE HAOUZ OF MARRAKECH

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Since independence, Morocco has launched ambitious plan to develop its agricultural land to cope with climate contingencies. With the economic recession of the 1980s, Morocco has adopted, under the requirements of donors, the Agricultural Structural Adjustment Programme. Then, through a new law that reflects the will of the State to implement the concept of Participatory Management of Irrigation, water users' organizations (Irrigation water Users Associations AUEA) have been entrusted to responsibility for managing irrigation systems.

The search for a sustainable development favors the emergence of a new “post-modernist” vision of the management of the water resources. This new context, marked by the disengagement of the State, imposes a redistribution of the roles between the State, the private one and the rural organizations in the development. Regarding management of the irrigation, the corollary of the disengagement of the State is the dialogue, the empowerment and the participation of water users.

This research aims to highlight the concept of participative management in irrigation, badly explored in spite of the increasing recognition of the role which we attribute him. It helps to contribute to a reflection on the revitalization of AUEA in the zone of study "the perimeter of Haouz of Marrakech", to direct itself towards a new methodology of approach based on the principles of the participative democracy and the design of institutions representative, qualified and autonomous, able to make peasant organizations institutions, that can properly perform the assigned functions.

The aim is also to show the importance of integration in the participatory approach, the expertise of peasant in irrigation management for the institutional transition in these mostly traditional irrigation systems leads to effective, sustainable and equitable situations.

The study of the functioning of the systems of irrigation, within the framework of a collective action, so allows to report capacities of the local communities to be managed effectively and durably waters of irrigation under the angle of the conciliation between socioeconomic development and protection of the ecosystems.

Keywords: sustainable development, irrigation, Participatory Management of Irrigation.

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APPLICATION OF HYDRUS-1D MODEL ON A WHEAT CULTURE UNDER A SEMI-ARID CLIMATE

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INTRODUCTION

Evapotranspiration is one of the major components of the hydrologic cycle is highly important in studies relevant to design and management of irrigation systems. The knowledge of the evapotranspiration of natural ecosystems and plant populations is of fundamental importance in several branches of science, research and practical uses [1]. In physical sense, evapotranspiration (ET) is the sum of the evaporation (E) from the water and soil surfaces and the amount of water transpired by plants (transpiration, T). The aim of this study was to estimate actual evapotranspiration at semi-arid climate Marrakech region (Morocco)-annual scale using HYDRUS-1D model developed by Šimůnek et al., 1998[2].

An inverse analysis method was conducted to determine the hydraulic properties of soil [3] based on Levenberg-Marquardt algorithm by minimizing the objective function, defined by the difference between observed and computed data. The numerical model HYDRUS-1D is applied and validated in on a wheat culture under on semi-arid climate in the Marrakech region. Model results are compared with observations data especially soil moisture(SM) and evapotranspiration. This results shows a good agreement between (SM, ET) mod and (SM, ET) obs.

Model simulation is appropriate tool for identifying best irrigation and a good estimation of the evapotranspiration management.

MAIN RESULTS

Fig 1 presents the values day of moisture measured and simulated for both first layers 5cm which plays a significant role in the phenomenon of evapotranspiration.

According to this figure, it is noted that the evolution of the soil moisture simulated by the model follows the pattern of the moisture measured for a layer of 5cm. In spite of the difference observed between simulated and measured curves which can be explained by the fact why the TDR give local values (the point where the instrument was inserted) and the model gives the simulations balanced on all point of the layer.

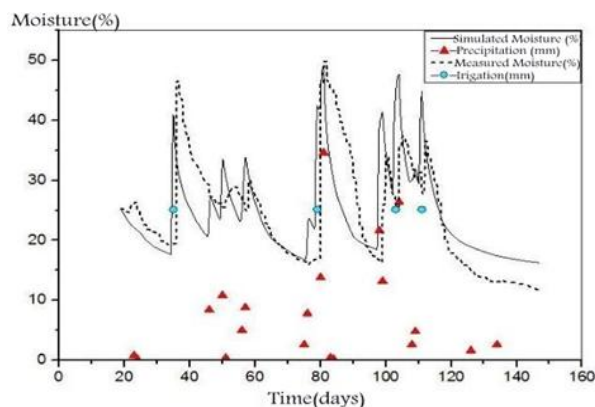


Fig .1 Water content simulated and measured for a 5 cm of depth: During 2003.

KEYWORDS: Evapotranspiration; HYDRUS-1d; MODEL; Irrigation; Water.

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I will like to address my sharp thanks HADDOUT soufiane, HACHIMI Mustapha for their help.

References

- [1] Ezzahar J., Spatialization of flows of energy and mass has the interface biosphere in the semi areas – arid by using the method of scintillation, Thèse de Doctorat Nationale a L'université Cadi Ayyad-Marrakech , (2007), pp. 29-30
- [2] Šimůnek Jirka et al. The HYDRUS1D Software Package for Simulating the One-Dimensional Movement of Water, Heat and Multiple Solutes in Variably-Saturated Media, CALIFORNIA 2012.
- [3] Qanza Hamid et al. Numerical Estimation of Unsaturated Soil Hydrodynamic Parameters. International Journal of Innovation and Applied Studies, vol. 8, no 2, 2014, p. 653.

PROJECT OF ECO-HAMMAMS: AN INNOVATIVE CONCEPT FOR OPTIMUM MANAGEMENT OF ENERGY AND WATER IN HAMMAMS (COMMON OF DAR BOUAZZA)

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Hammams are essential elements of social life and an integral part of Morocco's cultural and social heritage. Unfortunately, studies done on hammams show that they consume large amounts of water (60- 120m³ / day / hammam) and fuel wood (wood 1.5tonnes / day / hammam) especially in water-stressed countries. These high consumption automatically harm the environment because of waste water discharged directly into the receiving environment for most rural and suburban hammams one hand, and greenhouse gases produced by burning wood other hand. Try to reduce these releases for these hammams therefore present an environmental and sustainable development challenge that we must meet.

The objective of this study is twofold:

- For waste water, it is proposed to implement a demonstrative model based on a new and innovative technology: the waste water is treated with a compact system for an reuse for irrigation, watering, ...
- For the energy aspect, makes proposals that would improve the energy efficiency of a traditional Hammam: use of improved boilers, renovation of premises allowing decrease in losses of heat through the walls, use of energy sources renewable.

The laboratory tests for different scenarios been made to develop the most adapted method to local conditions. After identification and characterization of liquid discharges, we have designed and implemented two filters planted in a laboratory scale, using the pozzolan and gravel with defined sizes as filter materials. The filters were powered by the rejection of a liquid decanted from a Hammam model.

The results show that the reduction of organic pollution parameters is satisfying, especially due to the combined action of macrophytes, bacteria and physical barrier of the the filter body. Indeed, for a settling of 48 hours waste water we got a good elimination of suspended solids in the settling pond and a good fall of the three physico-chemical parameters (COD, BOD₅ and TSS) for the pozzolan filter planted reeds.

KEYWORDS: Water, sewage, wastewater, planted filter, reuse, Hammam, sustainable development, energy wood, pozzolan.

CLIMATE VARIABILITY IMPACT ON GROUNDWATER IN ZAHREZ BASIN (ALGERIA)

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The water resources which are available in Algeria are limited [1]. They are also subjected to cyclical extremes variations i.e. succession of cycles of severe drought [2, 3]. The drought observed during these last years in Algeria has also affected those located more to the south, characterized by semi-arid to arid climate. The decrease in rainfall and consequently that in runoff might penalize development projects linked with water supply. The Zahrez basin (Fig.1) is one of the endorheic basins of the vast steppes region in the central northern part of Algeria. The Zahrez hydrological basin covers approximately 8,989 km². The catchment lies between longitudes 2° 15' to 4° 08'E and latitudes 34° 35' to 35° 30'N. The area is characterized by a semi-arid climate, typically Mediterranean, with an irregular annual rainfall. The mean annual rainfall and potential evapotranspiration are 250 and 1380 mm, respectively, exceeding rainfall for most of the year[4].

This work deals mainly with a statistical analysis of the precipitation regime to assess its temporal variation in variability in Djelfa region (Zahrez watershed). For this, time series and a principal component analysis are performed on rainfall series representing annual precipitations of nine meteorological stations for the period 1973 to 2007. To detect possible changes in rainfall patterns, we used a number of statistical tests (Pettitt (1979), Lee Heghinian (1977), U Buishand (1984) and the segmentation method of Hubert (1989))[5]. The study of temporal variability and annual rainfall time series, using the reduced centered index of Nicholson, showed the existence of an alternation of wet (1974-1982) and dry periods (1983-2007) for 67 % of stations. The different statistical procedures applied to the series of rainfall showed breaks for Charef, Benhafaf and Ain Maabed stations.

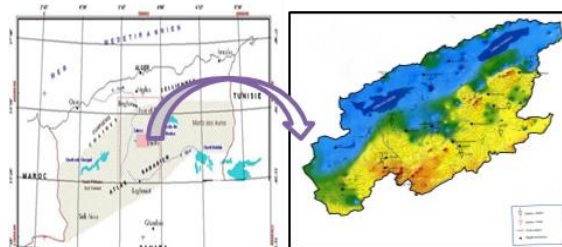


Figure1. Studied basin

KEYWORDS: climate variability; groundwater; semi-arid climate; time series; statistical tests

REFERENCES

- [1] Leila Hamlaoui et al., Nat Hazards, vol 65, 2013, pp.1293–1311
- [2] Ahmed Kettab., Desalination and Water Treatment, vol 52, 2014, pp 1965–1966
- [3] Ahmed Kettab et al., Revue des sciences de l'eau, vol 21 (2), 2008, pp 24
- [4] Fatah Bouteldjaoui ., Revue Nature & Technologie , vol 07, 2012, pp 109-116
- [5] Pettitt A.N., Appl. Statist, vol 28(2), 1979, pp 126-135

THE ECONOMICS OF HYDRODAM REOPERATION IN A CHANGING CLIMATE: THE CASE OF AKOSOMBO & Kpong DAMS, GHANA

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The construction of the Akosombo Dam for hydropower production has contributed significantly to the economic development of Ghana and other riparian countries. Constructed in 1965 with a total installed capacity of 1020 megawatts of electric power, the dam provides electricity to Ghana (more than 70% the national demand) and the neighboring countries of Togo and Benin. The dam also generates additional local benefits such lake transportation, increased fishing, new farming activities along the shoreline, and tourism. However, the construction and operation of the dam has changed the downstream flow regime from a highly dynamic one towards a steady flow regime to optimize the production of hydropower and irrigation potential, affecting the downstream ecosystems and ecosystem services that are dependent on this dynamic flow regime. The focus on hydropower generation which is of significant national interest has come at a cost of local communities and their livelihoods. The changing climate in the region has compounded the scale and intensity of the problem. In recent times, re-operating dams has gained interest for restoring downstream ecosystems and improving the livelihoods of riparian communities. This necessitates among other things a critical economic analysis (the costs and benefits) of re-operating the dams that could provide essential decision-support evidence whether or not to engage in re-operating dams.

This paper presents a cost-benefit analysis of four alternative reoperation hydrograph scenarios for the Akosombo and Kpong dams in Ghana in order to generate evidence on the economic efficiency of dam reoperation. Given the complexity of the problem at hand, we pursued a step-by-step methodological approach: (i) identify the multiple ecosystem services and other benefits and cost components affected by the re-operation of the dams; (ii) define a number of plausible water flow regime scenarios; (iii) assess the actual/potential impacts (positive or negative) of each proposed scenario on the flow of ecosystem services and other benefit/cost items; (iv) economic valuation of the ecosystem services under different scenarios using a range of market and non-market valuation approaches; and (v) evaluate the economic efficiency of scenarios using certain key decision criteria commonly used cost-benefit analysis such as the NPV and IRR. A total of 6 major benefit items (irrigation, hydropower, flood recession agriculture, aquaculture, shell fish, and finfish) and 8 cost items (irrigated area flooded/intakes damage, health impact-malaria, health impact-bilharzia, aquaculture-cage damage, aquatic weeds removal cost, sediments-dredging cost, infrastructure damage, and domestic water treatment cost) were identified and included in the economic analysis under different flow scenarios. The cash flow of these benefit and cost components were generated for a time horizon of 35 years (2015-2050), 2015 being as a base-year. Key factors that could potentially affect the values over time, such as changes in prices and climate change were considered in the valuation exercise.

The current flow regime is very beneficial for the main economic components; hydropower, aquaculture and large scale irrigation. However, restoring natural flow conditions contributed more towards improving rural livelihoods such as fisheries and flood recession farming. On the other hand regular flooding affected the economic activities of large scale investors while

threatening the livelihood of riparian communities in terms of infrastructural damage, lack of access to freshwater for domestic use and potential for dry season smallholder agriculture. There seem to be no ideal scenario to satisfy all the components affected by reoperation; however there exist a large potential for economic development in the Lower Volta. It is therefore recommended that in the event where reoperation is not feasible, riparian communities should be empowered with alternative livelihoods.

KEYWORDS: ecosystem services; Akosombo; climate change; hydropower; irrigation

Acknowledgement:

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APPLICATION OF TRITIUM AND CARBONATE ISOTOPES OF THE TLEMCCEN MOUNTAINS KARSTIC SYSTEMS (ALGERIA) FOR DESCRIPTION OF THE REGIONAL GROUNDWATER FLOW

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The Tlemccen Mountains in the North-West of Algeria are formed by carbonate massifs of upper Jurassic age. The mountains are surrounded by regions with high population density and exerting high water demand. Karst systems of this region, mainly associated with limestone-dolomites rocks, are characterised by marked heterogeneity related to the presence of fractures and drainage net-works (underground conduits). This heterogeneity induces a wide spectrum of water origin, transfer mechanisms and residence times. Hydrological measurements at the outlet of karstic system cannot easily characterise the functioning of the different systems.

Based on isotopic approaches, this work aims at the understanding of the functioning of karstic aquifer systems in Tlemccen Mountains, Algeria.

The isotopic compositions contained in groundwater are abundantly used to obtain information about the functioning of the karstic systems. The tritium as radioactive isotope of water molecule is an inert tracer to indicate the residence time of groundwater. The carbon-14 of dissolved inorganic carbon is used as tool in estimating the age of ground water [1]. In arid and semi-arid regions where the availability of the resource in water is limited to groundwaters, these methods offer a powerful tool in understanding groundwater origin, recharge and flow.

The relation between the monthly precipitations and their contents in tritium show the different origins of rainfall having prevailed. During the spring and winter seasons, the rainfalls are engendered by the movement of the Mediterranean fronts to south, clouds constituted essentially by navy water steam give poor rains in tritium (effect of dilution of the activities tritium). During the period May-August rainfalls are generally stormy rains relatively charged in tritium. The measured contents of tritium in groundwaters allow distinguishing three categories of results which corresponds to three types of functioning:

- The contents inferior to 0.2 TU, indicate old waters, this correspond to confined karstic systems with a deep recharge;
- The contents ranged from 2 to 6 TU, correspond to mixture between old water and actual water;
- The contents included between 6 and 30 TU, it is about mixture of actual and fresh waters. This corresponds in perched karstic systems.

The distribution of both isotopes of the carbon ($\delta^{13}\text{C}$ and ^{14}C) indicates in a general four types of water:

- Recent waters of the karstic systems perched with contents ^{13}C ranged from -12.50 to -14.55 ‰, the activities ^{14}C are grouped between 80 and 114 pcm;
- Mixtures of fresh and actual waters, with concentrations $\delta^{13}\text{C}$ included between -10 and -12 ‰, the activities ^{14}C , varies between 45 and 80 pcm. This corresponds to an unsaturated zone relatively weak;

- The third type corresponds to actual waters with contents $\delta^{13}\text{C}$ generally lower than -10 ‰ and activities ^{14}C between 20 and 60 pcm;
- The old waters with activities ^{14}C lower than 16 pcm and contents in ^{13}C superior to -10 ‰.

The classification of the systems according to the contents $\delta^{13}\text{C}$ balancing calculated distinguishes three families classified according to the degree of opening of the systems:

- waters stemming from an evolution in opened system,
- waters derived from an evolution in closed system,
- waters evolved under mixed conditions

A trend of decreasing ^{14}C activity associated with a change towards heavier $\delta^{13}\text{C}$ values confirms that geochemical reactions are affecting the ^{14}C concentration along the groundwater flow system, which is particularly evident in karst groundwater

The content of ^{14}C , ^{13}C and ^3H confirm the compartmentation of the karstic systems and the complexity of their functioning hydrodynamics.

The results of this isotopic approach that were able to draw the general functioning of the karstic systems of the Tlemcen Mountains should be combined to those of the hydrochemistry. For better understanding of the functioning of the systems and its vulnerability, it is now necessary to proceed to a monthly isotopic follow-up of at least from one or two springs by type of aquifer system during one or two hydrological cycles.

Keywords: Algeria - Groundwaters - Hydrodynamic functioning - Isotope - Karst systems

INFLUENCE OF CLIMATIC CONDITIONS ON GROUNDWATER RESOURCES IN SEMI-ARID ZONE, IF THE PLAIN OF SAÏSS (NORTHERN MOROCCO).

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Looking at their climate regime, the plain of Saïss is part of semi-arid areas of Morocco which are subject to the influences of the rapid increase in population and their needs for water and the effects of climate change increasingly worrisome. This situation presents a strong constraint for the reserves of sensitive groundwater in the plain. The aim of this contribution is to highlight the existence of climate variability, manifested primarily by variability in the amount of rainfall and irregularities in the plain studied and highlight its impact on food of groundwater reserves, in the surface water table. To do this, various data (rainfall and piezometry) and methods (The Standardized Precipitation Index (SPI), homogeneity test and cumulative rainfall, Statistics Buishand, test PETTIT, Bayesian method LEE and HEGHINIAN and procedure Hubert segmentation) were used. In the light of the results obtained, a climate variability characterized by alternating wet, normal and dry phases were identified in the study area. The indices and statistical methods indicate the existence of a break in 2008-2009 manifested by changes in rainfall patterns. The symptoms of this climatic variability from affecting groundwater resources. A significant decrease in the static level of the surface water table appears in the piezometers witnesses to a low level in 2002/2003, indicating an anomaly in the sampling report / recharging the superficial aquifer.

Keywords: climatic changes, superficial aquifers, semi-arid plain of Saïss.

CLIMATE CHANGE IMPACTS ON THE BENI AMIR AQUIFER, MOROCCO

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The aquifers of OumErRbia basin show a significant imbalance between the groundwater input and output because of their overexploitation for agriculture and drinking water. Indeed, in 2012, groundwater extractions reached 608 million m³ while groundwater potential was only 347 million m³, yielding a deficit of nearly 300 million m³. Moreover, climate change will have a certain impact on the future of these resources. A recent study conducted in 2013 by the OumerRabia Hydraulic Basin Agency and the World Bank, predicted an increase in the mean annual temperature ranging between 0.1 and 1.4 °C by the period 2010 - 2030. In addition, the average annual rainfall will decrease by about 200 mm. The demand for irrigation water and drinking water will yet increase given the population growth coupled with progressive economic development. Climate change will adversely have an impact on aquifers recharge and the level of their water table, and consequently, the gap between supply and demand will increasingly rise.

The Beni Amir water table develops in the Tadla plain on the right side of the OumErRbia. Its area is estimated to 1500 km². The aquifer of Beniamir is characterized by a renewable groundwater potential of 30 million m³. Its water table shows an unbalance due to overexploitation. Indeed, the inputs volumes from rainfall and irrigation return are 8 and 94 million m³ respectively, while withdrawals for irrigation and drinking water are 65.7 million m³, thus a deficit amounting to nearly 50 million m³ [1].

During 2011-2013, the River basin Agency of OumErRbia conducted a series of studies with the support of the World Bank to describe climate evolution in the region by 2030/2060, and to characterize the possible impacts of climate change on water resources and on the balance between supply and demand during the period 2011-2040. Dynamical downscaling method was used to determine the future projections of climate, through three general circulation models (GCMs) [2]. Two models show a reduction in rainfall from 0.01 to 0.3 mm per day per decade in the period 1971(81) to 2065 and one model shows an increase in rainfall between 0.01 and 0.1 mm per day per decade over the same period. The three models agree on an increase in temperature, which varies between 0.05 °C and 0.7 °C per decade for the period 1971(81) to 2065.

Evolution of registered precipitation and temperature data shows that climate trends converge towards an increase in temperature and a decrease in precipitation with the alternation of wet and dry years.

To assess the impact of these climate variations on Beni Amir aquifer, we studied the evolution of groundwater levels of some wells located in the aquifer. The graph shows a significant drop in the groundwater level (figure 1).

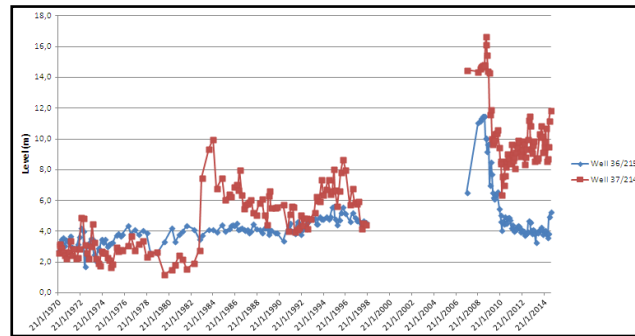


Figure 3. Evolution of the groundwater level from two wells in the Beni Amir aquifer

To better understand the relationship between the variability of climate and water resources and to clearly define the impact of climate change on groundwater, several factors must be determined: The amplitude of the variation of temperature and precipitation compared to that of water levels, the aquifers response time to these variations and the estimation of recharge and evapotranspiration. Furthermore, we should look out for other factors such as over extraction and growing demands that influence groundwater resources, especially if we assume that temperature and precipitation remain unchanged.

In order to fill the gap between water supply and demand, climate change adaptation actions must be taken, in particular, the use of non-conventional water resources such as desalination of sea water, reuse of treated wastewater, rainwater harvesting, optimization of irrigation infrastructures and the adoption of projects of water transfer from other national basins with excess water.

KEYWORDS: Groundwater; Climate; Aquifer; Change; Basin.

STATISTICAL ANALYSIS OF HYDROLOGICAL REGIME IN NORTH-WESTERN ALGERIA (MACTA WATERSHED)

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INTRODUCTION

The Mediterranean semi-arid and arid areas are particularly affected by recurrent and prolonged drought and the issue of water is a real challenge in this century. Several studies have shown a decrease in rainfall Mediterranean basin since seventies. Reference [1] demonstrate that the second half of the 20th century shows a general decrease of 2.2mm / month / decade, particularly, the period from beginning eighties to late nineties, which saw a general drying over large parts of the Mediterranean. Reference [2-3] analyzed the seasonal variability of precipitation and its evolution throughout the Mediterranean area for the period 1901-1998, a negative trend appears for the winter rainfall.

In Algeria several studies show a significant decrease of rainfall since seventies particularly in the North-West regions during winter and spring seasons [4-5].

In this study, Macta watershed was selected to better assess the impact of climate variability on water surface in semi-arid region of Algeria.

MAIN RESULTS

The time series of 55 annual values (1950/1951-2005/2006) observed at two runoff stations has been selected and submitted to rupture tests to detect a break over the study period. Three statistical tests were used; Kendall test, Pettitt test and Hubert segmentation procedure. All the rupture tests indicate a break in 1976 with a decrease of about 37% and 57% respectively at "Sid Ali Ben Youb" (Fig.1) and "Three rivers" runoff stations. At the seasonal scale, the statistical tests reveal a significant decrease of flow in winter and spring that excess 50%. Therefore, the wet season seem to be the main cause of the hydrological drought. The number of years that have suffered a severe drought has been determined using standard stream flow index (SSFI). It appears that the decades of 90's and beginning of 2000 have experienced the most dries years. Finally, a comparison between the evolution of the mean annual flow and the average annual rainfall of the Macta watershed has been established and which highlights a good correlation between precipitation and flow. The statistical tests show a decrease around 30% of rainfall since 1976 which could be explain the downward trend of flow.

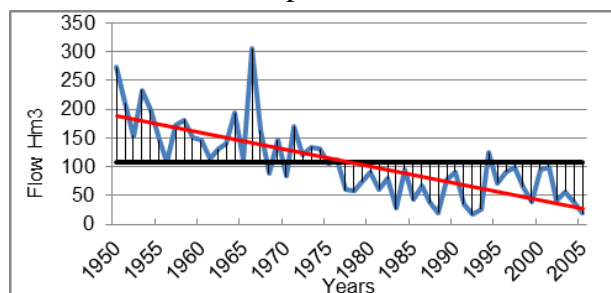


Figure 1. Flow evolution at Sid Ali Ben Youb runoff station.

References

- [4] Xoplaki E., et al., *Climate Research*, vol.14, 2000, pp. 129-146.
- [5] Jacobeit J., *Petermanns Geogr Mittl*,v.144, 2000, pp.22–33.
- [6] GiorgiF., *Clim Dyn*, v.18, pp. 675–691
- [7] Taibi S.et al, *IAHS Publ*, v.359, 2011,pp.191-197
- [8] Meddi M. and al., *Water Resour Manage*, n.24, 2010, pp.3817-3833.

PHYSICAL AND CHEMICAL ANALYSIS AND SPECIATION OF ARSENIC OF WATER PIT LAKES FROM THE ABANDONED MINE OF ZEIDA (HIGH MOULOYA, MOROCCO)

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In the Zeida abandoned mine, 26 to north of Midelt city (Morocco), five pit lakes called ZA, ZB, ZC, ZL1 and ZL2 originated from the Pb ore exploitation are currently used for irrigation, livestock watering and domestic use. To assess the pollution of lake waters by heavy metals and As, two hydrogeochemical campaigns were carried out (November, 2010 and October, 2012).

The 2010 campaign showed the lake waters are slightly alkaline ($8.02 < \text{pH} < 9.08$), their conductivity ranges from 510 to 14000 $\mu\text{S}/\text{cm}$, thus exceeding Moroccan irrigation standard (12000 $\mu\text{S}/\text{cm}$) for ZL1 lake. The concentrations of the major elements showed two different facies. ZA, ZL1 and ZL2 exhibit chloride and sodium facies while ZB and ZC exhibit carbonate and sulfate facies. The trace elements (Li, B, Sr, Zn) concentrations were higher in ZL1 ($\approx 11 \text{ mg/l Li}$; $\approx 2.4 \text{ mg/l B}$; $\approx 3.4 \text{ mg/l Sr}$; $\approx 0.3 \mu\text{g/l Cd}$) and ZL2 ($\approx 1.9 \text{ mg/l Li}$; $\approx 0.2 \text{ mg/l B}$; $\approx 4.5 \text{ mg/l Sr}$; $0.1 \mu\text{g/l Cd}$) lakes than the other lakes, jeopardizing the sustainable use of the water resource for local residents.

The 2012 campaign was focused on two lakes (ZA and ZL1) in order to characterize the fluctuation of heavy metals and As a function of the depth of the water lakes. The physical and chemical parameters (T° , pH, DOC, Eh, EC) are slightly variable with the depth in the lake ZA except the DOC (dissolved oxygen concentration), and they are slightly variable in the ZL1 lake except T° and EC. The major ions showed at the different depths that the waters of ZA and ZL1 lakes are chlorides and sodium facies. The heavy metals and As represent a variation with depth in the lake ZA, especially at 2 and 3m deep, but they remain inferior to the potability standard except for Pb ($18 \mu\text{g/l}$; stan $10 \mu\text{g/l}$) and As ($80 \mu\text{g/l}$; stan $10 \mu\text{g/l}$). In ZL1 lake, these elements are unchanged with depth and they are below the standards with the exception of As ($150 \mu\text{g/l}$) far exceeding the standard.

The speciation of arsenic differs considerably in the two studied lakes. In ZA, dimethylarsenic largely predominates, while in ZL1, arsenate As (V) is the only species detected. This suggests that in ZA, inorganic arsenic can be methylated by microorganisms or algae.

KEY WORDS: Pit lakes; heavy metals; arsenic speciation; abandoned mine; Zeida; Morocco

VARIABILITY OF ANNUAL PRECIPITATION IN NORTHWEST ALGERIA

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The western parts of Algeria have been characterized by a dry climate since the end of the seventies. This dryness is characterized by a remarkable severity and a persistent and significant rainfall deficit. This study of the continuing drought, using Markov chains, showed that the probability to have a non-dry year after a dry year is more important in the Centre than in the West of the country, and the probability to have two successive dry years is higher in the West than in the Central Plains.

For over thirty years, the northwestern and central parts of Algeria have experienced significant rainfall deficits that have resulted in a severe drought. This seriously affects the water resources used for drinking water supply and agriculture. To carry out this work, a number of rainfall stations representing the region were selected in order to constitute a database. Thus, five stations were selected with time series that cover sufficient information to enable us to study the continuing drought in the region and plains concerned. The continuing drought will be studied using the method of Markov chains.

In recent decades, northern Algeria has experienced a succession of periods of deficits and periods of rainfall surpluses.

The most brutal and significant fluctuation (in statistical sense) is observed around the 1980s, during which we notice a quite significant decrease in annual rainfall. This period of deficit is characterized by its intensity and duration. This reduction amounts to more than 36 % in the Mascara region and in the far west of Algeria (agricultural regions: the plains of Ghriss and Maghnia). However, in the centre of the country, the Mitidja plain, this reduction is of the order of 20 %.

The study of the continuing drought, using Markov chains, showed that the probability of having a non-dry year after a dry year is higher in the centre of the country than in the west and the probability of having two consecutive dry years is higher in the west than in the central plains.

KEYWORDS: Precipitation; Variability; Drought; Northwest Algeria

PAST AND FUTURE TRENDS IN TEMPERATURE AND PRECIPITATION IN MOROCCO

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Morocco is located between the arid regions of the Western Sahara and the Mediterranean and Atlantic regions. The climate of Morocco is mostly semi-arid with warm to hot, dry summers, occasional droughts, and mild, relatively wet winters. We first provide a summary of Morocco's climate trends during the last four decades. Indices were computed based on a daily set of observations of temperature and total precipitation using a consistent approach recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI). Trends in these indices were calculated at 20 weather stations from 1970 to 2012 (Filahi et al, 2015). Twelve indices were considered to detect trends in temperature. A large number of stations have significant trends and confirm an increase in temperature, showing increased warming during spring and summer seasons. The results also show a decrease in the number of cold days and nights and an increase in the number of warm days and nights. Increasing trends have been found in the absolute warmest and coldest temperatures of the year. A clear increase is detected for tropical nights and diurnal temperature range. Eight indices for precipitation were also analyzed. In general, the trends for the precipitation indices are much less significant than for temperature indices and show more mixed spatial patterns of change. Heavy precipitation events do not exhibit significant trends except at a few locations in the north and central parts of Morocco, with a general tendency towards drier conditions. In order to investigate the future climate characteristics, we compared four different regional climate model (RCM) simulations participating in EuroCORDEX (KNMI, IPSL and CLM) and MedCORDEX (CNRM) experiments. All simulations are available at a 12 km spatial resolution and they cover the northern part of Morocco, where most of the selected stations are located. The use of high-resolution models at 12km allows a good reproduction of orography. An evaluation of the ability of the different RCMs to reproduce climate indices of extremes in Morocco is first performed. To assess model performance, we use metrics such as Taylor diagrams to quantify the overall correspondence between simulated and observed fields. Overall, on most indices the four RCMs driven by reanalysis data are able to reproduce the spatial patterns and the inter-annual variability. The average projections provided by the four models are considered to provide an overview of projected changes in climate extremes indices defined by the ETCCDI. We present the results for two RCPs (4.5 and 8.5) and for two time period (2036 - 2065 and 2066 - 2095). Temperature is projected to increase in most parts of Morocco. For precipitation, most simulations agree on a decrease in precipitation totals, in particular in southern regions. For extreme precipitation, a much lower agreement between models is found.

KEYWORDS: climate change; extreme event; ETCCDI; CORDEX; MOROCCO.

MOROCCAN ARTISANAL FISHERIES AND CLIMATE CHANGE SMALL PELAGIC RESOURCES CASE

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Climate change is a threat to coastal ecosystems; these alerts will have biophysical and ecological impacts on species distribution and productivity of stocks and of some ecosystems. They act at different levels of biological organization, from the physiological disturbance of individuals to modifications of a community, and by local extinctions and / or extensions of some species.

Aware of the impact of climate change on marine resources in general and small pelagic in particular, the Department of Marine Fisheries of Morocco has implemented a strategy based on the strengthening of fisheries management measures and the protection of ecosystems for sustainable development of marine resources.

The small pelagic stocks, vulnerable to environmental and hydro-climatic conditions, are characterized by their natural variability of abundance that is in direct connection with the recruitment variability. Excessive fishing pressure accentuates the effects of this variability especially when it targets the sensitive phases of the stock.

Small pelagic, living on the surface or between two waters, consist of the Sardine *Sardina pilchardus*, the Mackerel *Scomber scombrus* and *Scomber japonicus*, the horse mackerel, *Trachurus trachurus* and *Trachurus trecae*, the Anchovy *Engraulis encrasicolus* and sardinella *Sardinella aurita* and *Sardinella maderensis*. These resources usually exploited by Moroccan coastal and offshore fleets, recently caught by artisanal fleet which there is only limited information.

This study proposes to carry out a technical description of the active artisanal fleet (engine and equipment, fishing operation and storage capacity, etc.); quantifying operating indicators (fishing effort and catch) and environmental indicators (Meteorological, biological, physical, chemical, etc.) and finally illustrate the current and potential impacts of climate change on marine biodiversity, to quantify the magnitude and the impact on the exploitation of marine resources to the sustainable development of resources.

Considering the constraint to the lack of some data, because artisanal activity is almost completely anarchic and landings of small pelagic are under reported, it was necessary to use multiple data sources from several fishing stakeholders, i.e. data on the technical characteristics of the fleet, information on fishing activity, environmental data and landings marketing statistics.

Along the Moroccan coast, the peculiarities of the regions were considered in the analysis of various indicators. These features relate to hydro-climatic conditions, the distribution of fish stocks, the type of fishing unit and the fishing operation. Thus, four areas were identified: in Mediterranean coasts from Saidia to Jebha and from Jebha to Tangier; and in Atlantic coasts from Tangier to Safi and From Safi to Boujdor. The southern region Boujdor was ruled out because very few of artisanal boats in this region target the small pelagic.

Based on preliminary indicators of craft activity, a preliminary assessment of the fishing pressure is achieved by estimating the puncture of the artisanal segment in around 25% of total

production in small pelagic fish at the Mediterranean coast and the Atlantic North, while production in the central Atlantic region has not exceeded 4%. However the impact of the fleet on the marine ecosystem in general and in particular pelagic resources currently remains difficult to assess which requires regular scientific monitoring of the environmental component, the fleet dynamics and structure of landings.

KEYWORDS: *Artisanal fleet; climate change; small pelagic; indicators; impact*

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ESTUARINE RESPONSE DURING INFREQUENT ASTRONOMICAL EVENTS SIMILAR TO THE EXPECTED CLIMATE CHANGE IMPACT: CASE STUDY OF SEBOU RIVER ESTUARY (MOROCCO)

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Introduction

Estuaries are important ecosystems intensively used to sustain a wide range of activities such as human settlements, agriculture and transport. An estuary is a partially enclosed body of water where freshwater systems and rivers meet and mix with a salty ocean, becoming brackish. It is constantly shaped by water flowing from uplands as well as tidal cycles. Tidal motions arise as a response to forces associated with the interaction of the earth-moon-sun system. In other hand, estuarine ecosystems are affected by changes in global systems and cycles such as climate and weather cycles.

Estuarine ecosystem's also react facing infrequent events, such as periodical total moon or sun eclipses. During these phenomena, the gravitational pull on the ocean is strong, so the high water is at its highest point and the low water at its lowest point. Water level rise affects the hydrodynamic balance and can increase salt water intrusion into the river estuary, causing many ecological problems.

In this research, for the first time, the impact of both total lunar eclipse and total solar eclipse on the water level and salinity rise along an estuary is studied. The 28th September 2015 total lunar eclipse and 9th March 2016 total solar eclipse infrequent astronomical phenomenon were focused by the study and the Sebou river estuary (Morocco) is taking as an application area. Intensive salinity and water level measurements during these extreme events were recorded along the Sebou estuary and compared with normal situations. Also, an analytical model (Savenije theory) and numerical one-dimensional hydrodynamic and salinity transport model are applied to measurements.

The specificity of this study is that extreme events impact on estuaries can be similar to that of the expected climate change impact. Studying the effect of total lunar or solar eclipses gives opportunities to anticipate climate change effects, based on measurements rather than theoretical predictions alones.

Main Results

The Measurements shows salinity augmentation during extreme events compared with normal situations (figure 1). The maximum of salinity concentration is 30g/l during total lunar eclipse, 28.3g/l during total solar eclipse and less than 21 g/l in the normal situation. In other hand, figure 1 shows a notable water elevation rise during the two eclipses. Water level peaks at high tide increases by 13% (3.95 m) during total lunar eclipse and by 12% (3.85m) during total solar eclipse compared to the normal situation (3.2 m).

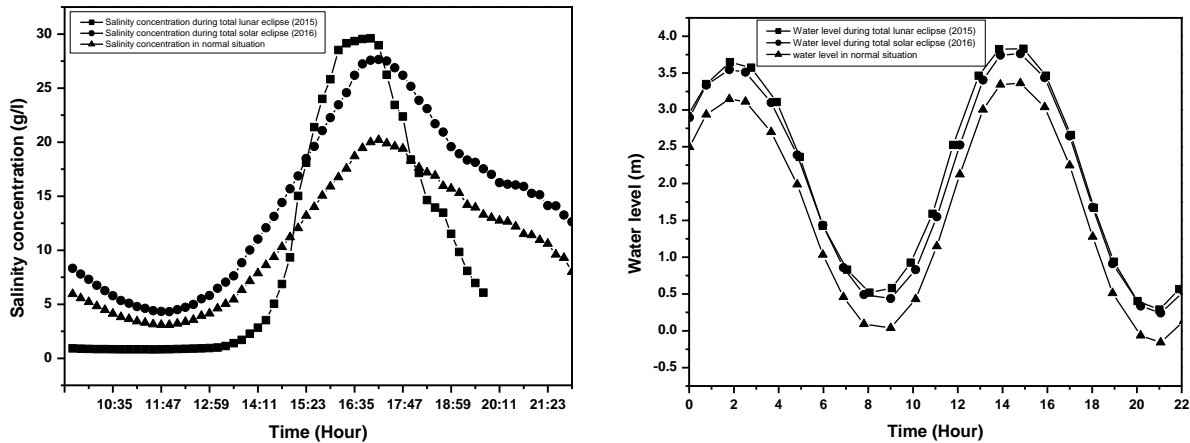


Figure 1. Salinity variation and water level during total lunar eclipse and total solar eclipse at Kenitra town station

In other hand, salinity and water level increase has affected many agricultural and drinking pumping stations located upstream of the estuary during eclipses. These stations are not influenced by the dynamics of the tide in normal situations. Finally, the impact of extreme events on the water quality of Sebou estuary should be considered by managers. Rapid interventions (pumping station closure for example), based on the predictions of mathematical models can thus be taken.

KEYWORDS: Sebou estuary; astronomical events; water level rise; salinity intrusion.

References

- [9] Savenije, H. H. (2015). Prediction in ungauged estuaries: An integrated theory. *Water Resources Research*, 51(4), 2464-2476.
- [10] Kettab, A. (2014). Water for all with quality and quantity: It is the concern of all! *Desalin. Water Treat.* (52) 1965–1966.
- [11] Haddout, S., Maslouhi, A., Magrane., B. Igouzal, M. (2015a). Study of salinity variation in the Sebou River Estuary (Morocco). *Journal of Desalination and Water Treatment*. DOI: 10.1080/19443994.2015.1091993.
- [12] Haddout, S., Maslouhi, A., Igouzal, M., (2015b). Predicting of salt water intrusion in the Sebou river 732 estuary (Morocco). *Journal of Applied Water Engineering and Research*. DOI: 733 10.1080/23249676.2015.1124029 .
- [13] Igouzal, M., Maslouhi, A. (2005). Elaboration of management tool of a reservoir dam on the Sebou river (Morocco) using an implicit hydraulic model. *Journal of Hydraulic Research*, 43(2), 125-130.

Topic 2

Advances in Water treatment, recycling and reuse

WASTEWATER TREATMENT BY FLOATING MACROPHYTES (*SALVINIA NATANS*) UNDER ALGERIAN SEMI ARID CLIMATE

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In most countries of the world, there has been growing and irreversible interest of the public for the protection of the environment. In Algeria, for instance, the water pollution problem is quite serious and therefore, purification techniques, including constructed wetlands (CWs) using macrophytes are recommended currently widely used for treatment of a wastewater. CWs become an interesting alternative for the treatment of wastewater, expressing seen the great benefits that they exhibit and low costs, they are less expensive to build and operate, are constructed directly on the wastewater discharge site, require little mechanized equipment and ultimately and are less sensitive to changes in pollutant loads.

Aquatic plants, emergent or free floating, acquire more and more importance in the world especially in countries with hot climates where the photosynthetic efficiency is important. The produced biomass is valued using bio-methanmethane production ation or by incorporation in animal nutrition (Sooknah&Wilkie, 2004). Floating or emergent aquatic plants, such as water hyacinth (*Eichhorniacrassipes* (Mart) Solms), water lettuce (*Pistia stratiotes* L.), *Salvinianatans* (L.), cattail (*Typhalatifolia* L.), andbulrush (*Scirpusvalidus* .L.), are able to treat wastewater with high purification yields.

In this study, we developed a macrophyte-based wetland system using floating aquatic plants, namely *Salvinia natans* to evaluate the efficiency and treatment performance filtration of domestic wastewater.

The present work is devoted to the treatment of domestic wastewater under climatic conditions of Algeria (semi-arid) through a system using two tanks planted with *Salvinia natans*.

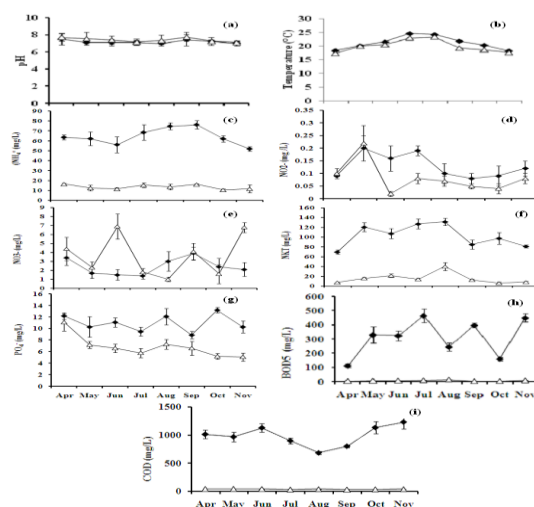


Fig. 1: Time-course of change in Temperature (a), pH (b), $\text{NH}_4\text{-N}$ (c), $\text{NO}_2\text{-N}$ (d), $\text{NO}_3\text{-N}$ (e), TKN (f), $\text{PO}_4\text{-P}$ (g), BOD_5 (h), COD (i) throughout the period of study (Mean \pm SD).

The performance study and treatment efficiency of the system overall shows that the latter provides a significant removal of nitrogen pollution: total Kjeldahl nitrogen NTK (85.2%), Ammonium $\text{NH}_4\text{-N}$ (79%), Nitrite $\text{NO}_2\text{-N}$ (40%) also, a major meaningful reduction of biochemical oxygen demand BOD5 was observed at the output of the system (96.9 %). As BOD5, the chemical oxygen demand (COD) removal was higher than 95 % at the exit of the two tanks. A moderately low yield of phosphate-phosphorus ($\text{PO}_4\text{-P}$) was achieved with values not exceeding 37 %. In general, the quality of treated effluent meets the Algerian standard of discharge and which allows us to select a suitable species in constructed wetland treatment systems under semi-arid climate.

Keywords: Wastewater treatment, Nutrient removal, *Salvinia natans*, semi-arid climate.

NANOSTRUCTURED ZNOFORPHOTOCATALYTIC DEGRADATION OF METHYLENE BLUE:A WATER ORGANIC POLLUTANT

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INTRODUCTION

Textile industries use highly toxic and non-biodegradable organic dyes, which can be carcinogenic and genotoxic to humans [1].

The Methylene blue (MB) is a heterocyclic organic dye, frequently used in textile, cosmetic and pharmaceutical industries. MB can cause permanent injury to humans and animals on inhalation and ingestion. The risk of the presence of this dye in water may be arisen from the burning effect of eye, nausea, vomiting and diarrhea [2]. This why MB must be removed from industrial effluents before the water is returned to the environment.

Therefore, decolorization and detoxification of organic dye effluents have taken an increasingly important environmental significance in recent years [3,4]. Most conventional methods for the removal of dye pollutants such as adsorption on activated carbon [5], ultrafiltration [6], reverse osmosis [7], etc. are non-destructive and merely transfer pollutants from one phase (for example, aqueous) to the other (for example, adsorbent). The photocatalysis has shown a great potential and is extensively employed, because of its capacity to degrade recalcitrant chemicals in both gaseous and aqueous systems.

Among photocatalyst, nanostructural zinc oxide's (ZnO) is used to degrade organic contaminants in air and water and to convert them into benign materials safe for the environment and humans [8]. Nanoscale ZnO exhibits high photocatalytic activity because of its numerous active sites and significant surface area [9].

MAIN RESULTS

The photodegradation of MB was carried out under visible light with nanostructured ZnO catalyst easily obtained by a precipitation method. It was found to be very efficient photocatalyst with high activity. Figure 1, show UV-visible absorption spectra of aqueous solution of MB in the presence of ZnO and an oxidative agent at different reaction times. In addition, the kinetic study of the photodegradation reaction of the dye follows a pseudo first order.

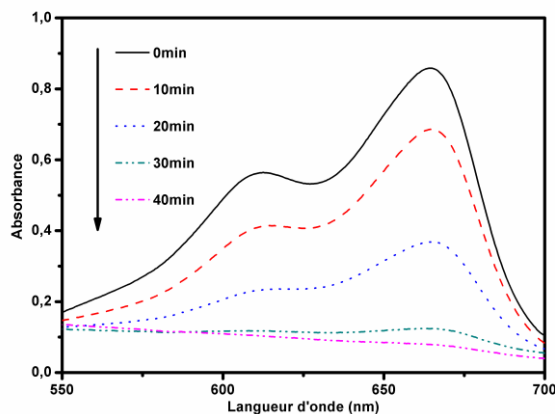


Figure 2. UV-visible spectra obtained during the MB photodegradation in the presence of ZnO nanoparticles

Figure 3.

References

- [1] R. Kant, Textile dyeing industry an environmental hazard, *Nat. Sci.* 4 (2012) 22–26.
- [2] B. Mokhlesi, J.B. Leikin, P. Murray, T.C. Corbridge, *Chest* 123 (2003) 897.
- [3] D. Brown, A. Mark, S.C. De Vito, *Crit. Rev. Environ. Sci. Technol.* 23 (1993) 249.
- [4] K. Rajeshwar, J. Ibanez, *Environmental Electrochemistry*, Academic Press, San Diego, (1997).
- [5] RihamHazzaa. Mohamed Hussein. *Environmental Technology & Innovation*.04, (2015), 36–517.
- [6] Suresh M. Doke, Ganapati D. Yadav. *Chemosphere* 117 (2014) 760–765.
- [7] R. Ironside, S. Sourirajan. *Water Research*. 01, Issue 2, (1967), 179–180
- [8] W. Lee, W. Chung, C. Lu, W. Lin, C. Chen. *Purif. Technol.* 98 (2012) 488–496.
- [9] L. Jing, Y. Qu, B. Wang, S. Li, B. Jiang, L. Yang, W. Fu, H. Fu, J. Sun, *Sol. Energy Mater. Sol. Cells* 90 (2006) 1773–1787.

VALORIZATION OF SEA'S WASTE IN THE ADSORPTION OF HEAVY METALS ENVIRONMENTAL CONSERVATION AND CHEMICAL ABATEMENT

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The relationship between human society and its environment has become a controversial issue. Indeed, the environment has reached a critical stage of degradation due to contamination by various activities related to man as industry and transportation among others.

This alarming situation could have prompted the question, from near or far, to find the pollution control means by offering cleaner industrial processes in order to preserve our water resources and plant and animal species.

In this context, it is proposed that this work is to study the relevance of the combined use of natural polymers namely chitosan (derived from shrimp waste) and alginates (derived from brown algae) in the adsorption of copper present abundant in industrial effluents.

To determine the optimum conditions for this interaction "metal biopolymers", several parameters were investigated such as pH, initial metal concentration, contact time, etc ... Kinetic studies have reflected that after only 30 minutes of interaction, we reached an adsorption rate of 60%.

The overall results showed that the composite "alginate-chitosan" turns out to have significant adsorption capacity towards Cu²⁺ ions. This might be an appropriate way to minimize metal concentrations of metalliferous waste in order to arrive at least to values below regulatory.

KEYWORDS: Adsorption, chitosan, alginate, Heavy metals, Copper, Composite

THE REMOVAL OF METALS (CD, CU AND ZN) FROM THE TENSIFT RIVER USING THE DIATOM *NAVICULA SUBMINUSCULA* MANGUIN: A LABORATORY STUDY

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Biosorption, the naturally occurring physiochemical process which passively concentrates and binds contaminants to cellular structures, can be used in biological systems for the removal of metal ions from polluted waters. It also has the potential to achieve better performance at lower cost than conventional wastewater treatment technologies. The aim of this study was to characterize the ability of the freshwater diatom *Navicula subminuscula* Manguin to biosorb cadmium (Cd), copper (Cu) and zinc (Zn) from aqueous solutions. This diatom is one of the most dominant microalgae in the Tensift River (Marrakech region, Morocco) into which industrial wastewaters are often discharged directly, without pretreatment. As the water from this river is used for irrigation, it represents a potential risk to the environment and human health. The choice of these three heavy metals is based on their high concentrations in mining waste and industrial wastewaters. Our results indicate that the biosorption of metals by *N. subminuscula* increased with the initial concentration of metal ions in the medium up to 100–130 mg L⁻¹. The maximum biosorbed metal amounts were 127 mg Zn, 90 mg Cu and 42 mg Cd by 16 x10⁸ cells L⁻¹ occurring within 30 min of contact, at 25°C. One of the most important factors affecting the biosorption of metal ions is the acidity of solutions because protons and metal ions compete on the negatively charged sites of the cellular surface. Different metal ions may have different pH optima, possibly due to their different chemistry in solution. The lowest biosorption values for all metal ions were observed at pH 2.0, and could be attributed to the high concentration of protons competing with Cd, Cu and Zn cations to bind with the biomass.

The increase in metal ion biosorption at higher pH values may be explained by the negative ionization of functional groups (such as –COO–) on the cell surfaces that serve as binding sites. The optimal pH values were 6.0 for Cu and 8.0 for Cd and Zn. At higher pH values, many negative charges are present on the cell surface; the ionic state of ligands such as carboxyl, phosphoryl, sulfhydryl, hydroxyl and amino groups promotes reactions with the metal cations. However, when the pH increases, the solubility of metals decreases and above a limiting value, metals are trapped in non-soluble hydroxylated complexes. The biosorption of all three metal ions followed the Langmuir isotherm. Competitive biosorption of Cd, Cu and Zn ions was also achieved. Fourier transform infrared spectroscopy revealed the different metal-binding functional groups on the diatom surface that are able to react with metals in the medium. The described batch studies provide significant information on the biosorption of Cd, Cu and Zn on the diatom *N. subminuscula* with respect to the optimum pH, cell concentration and temperature for the maximum removal of metals from aqueous solutions. Therefore, the widely available biomass of *N. subminuscula* in the Tensift River indeed has the potential to be used as an effective and economic material for the removal of heavy metals from wastewater streams and tannery effluents, as found for *Planothidium lanceolatum* (Brébison) Lange-Bertalot in our previously study, and other freshwater diatoms in different environments.

KEYWORDS: *Navicula subminuscula*, diatom, biosorption, heavy metals, wastewater.

USE OF THE FRESHWATER DIATOM *NAVICULA SUBMINUSCULA* MANGUIN IN ECOTOXICOLOGICAL TESTS FOR THE ASSESSMENT OF WATER QUALITY: A LABORATORY STUDY

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In Marrakech (Morocco), an important pollution is generated by the tannery industry which discharges metals into the Tensift River, and mainly chromium (≈ 40 tons/year) [1]. Tannery wastewater flows directly into the environment without any treatment. So, Cr(VI) was detected in the Tensift River with high values exceeding International and National norms, especially at low river discharge and high activity of tanneries.

In Morocco, freshwater microalgae – and especially diatoms - are only used for ecological purpose or for diatom indice applications to evaluate river water qualities. There are only few studies on metal toxicity and on diatom ability to remove metals from the environment. The objective of this study was to investigate the ability of the diatom *Navicula subminuscula* Manguin, to tolerate chromium by the determination of a share of the toxic effect of Cr(VI) under simulated environmental conditions and to evaluate the effect of various parameters including contact time and pH. Biosorption isotherm was applied to fit the experimental data.

The present study reports the ability of the diatom *Navicula subminuscula* to remove hexavalent chromium [Cr(VI)] from aqueous solutions in batch systems under varying ranges of pH, contact time and initial ion concentrations by the determination Cr(VI) toxic effects and biosorption by this species. The results show a significant growth of *N. subminuscula* for Cr concentrations up to 10 mg L^{-1} . The growth rate decreases as a function of increasing concentrations of Cr(VI).

The cultures were made with Tensift River water (Marrakech, Morocco) and in the presence of Cr(VI) concentrations from 0 to 4 mg L^{-1} . But the culture with tannery effluent water grew with concentrations from 0 to 0.152 mg L^{-1} . The IC50 is 9.2 mg L^{-1} for the artificial growth medium tested which is more than that calculated with river water (4.45 mg L^{-1}) and tannery effluent water (0.088 mg L^{-1}). The percentage of Cr(VI) biosorption increases with the decrease of pH: 50 % biosorption was measured at pH 7 whereas 92 % was reached at the extreme acid pH.

The found linear plot of C_{eq}/q vs C_{eq} shows that biosorption follows the Langmuir biosorption model. The correlation coefficient was 0.993. At an initial concentration of 0.4 g dried diatoms per liter with an initial Cr(VI) concentration of 20 mg L^{-1} , the values for q_{max} and b were determined from the slope and intercept of the plot, and were found to be $94.97 \text{ mg Cr(VI).g diatoms}^{-1}$ and 0.16 L mg^{-1} , respectively. The wide ecological valence of this diatom to pollution parameters and the seasonal pattern of its life cycle are the main factors that make the biomonitoring of Cr(VI) by this species feasible.

Thus, *N. subminuscula* is very tolerant to Cr(VI) like *Planothidium lanceolatum* (Brébison) Lange-Bertalot, another diatom which is also dominant in the Tensift River. After these promising results, we will test the capacity of the diatoms to biosorb other potential toxic metals. Later on, practical applications of such techniques at larger scales would be useful for bioremediation of heavy metal polluted wastewaters since there is a lack of industrial wastewater treatment.

KEYWORDS: *Navicula subminuscula*, diatom, biosorption, chromium, tannery wastewater.

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STUDY OF THE ADSORPTION PROCESS OF TEXTILE DYES RBBR AND AG1 BY A MIXED OXIDE DERIVATIVE OF AN ANIONIC CLAY

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Different pollutants significantly harm our environment such dyes. Indeed, synthetic organic dyes are compounds used in many industrial sectors such as the automotive, chemical, paper and especially the textile sector where all the nuances and ranges of chemical families are represented.

The affinities between the textile and the dyes vary depending on the chemical structure of dyes and the type of fibers on which they are applied. It is not uncommon to find that during the dyeing process, 15 to 20% of colorants, and sometimes up to 40% for sulfur and reactive dyes are discharged with the wastewater which is mostly directly discharged into rivers without treatment.

In recent years, studies on the textile dyes have shown that they are among the most toxic elements, and are also generally carcinogenic to living beings. Their removal is considered as important as the removal of soluble colorless chemical contaminants.

Adsorption is one of the treatment processes, the most common in the clean water, and became an analytical method of choice, very effective and simple in use.

The work done during this study fits within the general framework of wastewater treatment. It was aimed to study the performance of an anionic clay calcined [Zn-Al-CO₃] (CLDH) on the aqueous medium holding two textile dyes namely Remazol Brilliant Blue R (RBBR) and Acid Green 1 (AG1). Our goal is to demonstrate the effectiveness of this method for the removal of these pollutants and optimize experimental parameters such as contact time, pH and mass ratio pollutant/CLDH.

The hydrotalcite-like compound (anionic clay) consists of brucitic sheets whose centers of octahedra are occupied by Zn and Al and the spaces between the sheets by the CO₃²⁻ anions and H₂O molecules. This material [Zn₂-Al-CO₃] was synthesized reproducibly by coprecipitation method at constant pH 10 as a metal ratio Zn/Al = 2 and a ripening time of 72 hours under mild agitation, then this material is calcined at a temperature of 500 °C during 5 h.

The study of the kinetics of the two dyes showed rapid adsorption process which reflects a high affinity of CLDH material for both dyes. The equilibrium at room temperature is reached after 12 h for RBBR and 3 h for AG1. This is confirmed by rapid kinetic modeling of the experimental data by the pseudo second-order model which involves chemisorption type adsorption mechanism.

The adsorption capacity depends on the initial pH of the solution. To pH greater than 7 or less than 5, there is a decrease in the amount retained respectively due to contamination with the carbonate ions and the partial dissolution of the matrix. However maximum retention is obtained with an optimum pH of 5 for RBBR and between 6 and 7 for AG1.

The study of adsorption isotherms, comparison with the retention of a carbonated phase of calcined and uncalcined, reveals that the first could be a good candidate for trapping such pollutants.

The amount adsorbed of the two textile dyes depends on the mass of adsorbent used.

The results of XRD and IR indicate that the retention is governed by two phenomena:

- Adsorption textile dye sites available on the surface reconstructed by carbonated LDH when the mass ratio dye/CLDH is less than or equal to 0.1.
- Adsorption + intercalation interlayer in the area when this mass ratio is greater than 0.1.

The removal of dyes in anionic form by CLDH gave satisfactory results. Under optimum conditions, the retention is total (100%) when the weight ratio dye/CLDH is between 0.38 and 0.68 for AG1 and between 0.20 and 0.40 for RBBR. Retention capacity reached 800 mg/g for AG1 and 1000 mg/g for RBBR.

Rehydration obtained mixed oxides (ZnO and Zn_2AlO_4) formed after calcination (500°C) of the starting material in the presence of pollutants gives a phase reconstruction hydroxycalcite with preservation of lamellar character (XRD, SEM).

Keywords : Anionic clay, Layered double hydroxide, Calcination, Dyes, Kinetics, Isotherms, Adsorption.

RETENTION DU REMAZOL BLEU BRILLANT R PAR UNE APATITE PHOSPHOCALCIQUE

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Les effluents aqueux chargés en colorants provenant de certaines industries (imprimerie, cosmétique, textile, etc.) sont des sources importantes de pollution de l'eau. Le Remazol bleu brillant R (RBBR) faisant partie de la catégorie des colorants utilisés en textile. L'adsorption de ces polluants représente l'un des enjeux environnementaux majeurs pour la recherche. Les phosphates de calcium ont déjà montré leurs grandes potentialités pour l'adsorption de molécules organiques. Pour contribuer à minimiser l'impact des colorants sur l'environnement, nous avons étudié l'adsorption du RBBR en milieu aqueux, en utilisant comme agent adsorbant, une apatite phosphocalcique synthétique (Hap).

L'influence de différents paramètres (pH, masse de l'adsorbant, concentration de l'adsorbat) a été réalisé en régime statique à température ambiante. Le colorant a été quantifié par dosage spectrophotométrique UV-visible.

L'adsorbant a été préparé à température ambiante et à pH 7,4 par double décomposition entre une solution de nitrate de calcium et une solution de phosphate d'ammonium.

Les résultats de la diffraction des rayons X, de la spectroscopie infrarouge et des analyses chimiques confirment que le solide préparé est un phosphate de calcium apatitique non stœchiométrique de basse cristallinité, exempte d'ions carbonate.

L'étude cinétique d'adsorption montre que le processus de fixation du colorant se déroule selon un processus relativement rapide.

L'examen de la rétention du RBBR à différents pH révèle que le processus de fixation du colorant par Hap est influencé par l'acidité du milieu d'incubation. Il apparaît que le processus d'adsorption est nettement favorable à des pH très basiques est défavorable vers des pH légèrement acides.

Les isothermes d'adsorption obtenues à différentes masses de Hap montrent que la capacité de rétention du matériau augmente lorsque sa masse diminue. En effet, la diminution de la masse de Hap dans la suspension entraîne l'accessibilité à un grand nombre de sites libres de l'adsorbant. Ces isothermes sont de types S. Ce résultat suggère que les molécules adsorbées par le matériau favorisent l'adsorption ultérieure d'autres molécules (adsorption coopérative).

La modélisation des isothermes montre que le processus de fixation de RBBR par Hap s'effectue selon la loi de Freundlich.

Mots clés: Apatite phosphocalcique, Remazol bleu brillant R, Rétention, Isothermes d'adsorption.

STUDY OF THE POSSIBILITY OF REUSING TREATED WASTEWATER FROM THE JIJEL WWTP (NORTH-EASTERN COAST OF ALGERIA) IN AGRICULTURE

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INTRODUCTION

Water is a vital resource becoming continuously scarce in Algeria and less renewable. It is currently the object of a competitive exploitation between the population needs, the agricultural needs and the industry that are all struggling over its limited availability. Besides, in Algeria, each has in memory the consequences of the recent and recurrent drought years and the draconian measures for water consumption rationing that came after (Kettab et al ; 2008). The wilaya of Jijel is part of the Sahel zone and littoral zones; thanks to favorable conditions; 41,17% of the whole surface are useful agricultural grounds occupied by different kinds of cultures (market gardening, olive, arboriculture, cereals, vine). Nevertheless only 14,4% of these grounds represent an irrigated agricultural surface and this is caused by several factors: pollution of fields and groundwater that obstruct and affect agricultural activity. The reuse of the purified wastewater of the WWTP of Jijel represents an expectable alternative for the preservation of the resource of good quality and the enhancement of the agricultural sector by limiting the overuse of industrial fertilizers.

MAIN RESULTS

The treatment plant is located at the western side of Jijel city; it was put into service in June 2008. The wastewater treatment mode is characterized by activated sludge at weak load. Daily volume arriving at the WWTP is about 11 000 m³/day knowing that the maximum capacity of the WWTP is of 30 000 m³/day. The WWTP is dimensioned to treat 150 000 inhabitants.

The accomplished analyses indicate that the physico-chemical parameters (Temperature, pH, electrical conductivity, SS, BOD, COD, NH₄⁺, NO₃⁻, PT) of purified wastewater are inferior to the norms implemented by the FAO, as well as the norms implemented by the WHO, except for Ammonium (6.98 mg/l) and phosphorus (3.99 mg/l) which slightly exceed the regulations. Nevertheless, the phosphorus has the advantage not to be leached in the underground water or surface water; it remains fixed and well absorbed by the soil particles (Zella et al; 2002).

The results of bacteriological analyses of the purified water of the WWTP show the existence of germs indicating a fecal contamination (1400 UFC/100ml) exceeding the WHO regulations (1000 UFC/100ml).

The average concentrations of metals trace elements (Pb, Zn, Mn, Cu, Fe) are very low, except for chromium (0,152 mg/l) and Cadmium (0.016 mg/l) which slightly exceed the recommended limits by the FAO (2003) for reuse in long term irrigation.

The annual volume of purified water of the Jijel WWTP being 401 5000 m³/year, allows us to irrigate almost 803 ha at the rate of 5000 m³/ha per year and enrich the soil by an average annual

supply of 39.5 kg/ha of Nitrogen, 20 kg/ha of phosphate, these concentrations cover a great part of fertilizing needs for several types of cultures in our agricultural region.

CONCLUSION

Within this study, we have demonstrated how the purified wastewater reuse of an urban center allows the agricultural valorization of a great surface, thus it allows agriculture to be supplied, in addition to water, with fertilizers that are contained in purified wastewater, particularly Nitrogen and phosphorus that enhance the outputs of the cultures (Nakib et al ; 2014).

KEYWORDS: Purified wastewater, fertilizing, Reuse, Agriculture

Acknowledgement

This study is included in the activities of the Research Laboratory of Water Sciences (LRS-EAU) of the National Polytechnic School (NPS) managed by Pr Ahmed KETTAB within the IRRIGATION ERANETMED Project. We would really like to thank warmly its Coordinator Pr Massimo DEL BUBBA as well as our partners, the team leaders: Pr. *Maria C BRUZZONITI*; Pr. Naaila OUAZZANI, Dr Nesrine BOUJELBEN, Pr Emad Al-Karablieh; Pr. Laila Mandi for their deployed and consented efforts to succeed at this project.

EVALUATION OF THE FERTILIZING SUPPLY OF THE BY-PRODUCTS OF THE WWTP OF MEDEA (ALGERIA)

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INTRODUCTION

The scarcity of conventional water resources as well as the deterioration of their quality, represent particularly for Algeria, considering its Mediterranean climate which goes from arid to semiarid, a major issue and important preoccupation limiting the implementation of hydraulic programs aiming for development and service improvement, which negatively affects the well-being of citizens and threatens the destiny of future generations. Despite its insufficiency, there are several uses for this resource; household, agriculture, industry, tourism...etc. According to [1] Algeria has a global mobilizable hydraulic potential that does not exceed 13.2 billion cum of water, leading to an annual volume of 412 cum to each citizen considering all uses. This theoretical number is indicating a situation of severe water scarcity obstructing all the country's development.

The rationalization of the use of conventional water resources has become an imperative management. Thus, following the path to sustainable development, the agricultural reuse of purified waste water and regenerated mud after treatment, appears as an alternative option for the preservation of the hydraulic resource and the environment and the promotion of the agricultural sector.

MAIN RESULTS

It is around this axis that articulates this work based mainly on the ability for purified waste water and generated mud of the WWTP of Medea to be reused in agriculture. To accomplish that, analysis on by-products, have been done at the laboratories. The obtained results, projected and compared to the recommendations of the FAO and the WHO norms, have lead to the following conclusions:

- The purified water of the WWTP of Medea, despite its high salinity, is reusable for irrigation of some species which are tolerant to salt and on well drained and leached soils. Their content of nitrates is approvable and does not represent any noxious effect. In case of high amounts, cultures with multiple cuts and deep-rooted are very efficient for Nitrogen consumption and avoiding both its accumulation in the soil and its migration.

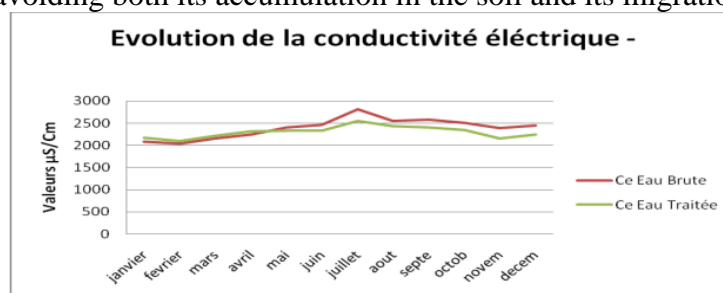


Figure 1. Evolution of electrical conductivity of both wastewater and purified water

The high concentration of fecal coliforms keeps this water from being able for reuse without chlorination.

- The purification mud with a C/N of 7.32 constitutes an important availability and a fast mineralization of Nitrogen of which the leaching could be avoided by spreading the mud during the growth period of the plants. This ratio is related to the relatively low quantity of organic matter that it contains indicating a stabilized mud. La which could be considered as a fertilizer in addition to an organic amendment.

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References

- [14] ZELLA .L, 2007, l'Eau pénurie ou incurie, Université Saad Dahleb de Blida, Office des Publication Universitaires, édition : 2.02.4894.ISBN : 978.9961.0.1059.4, 144pp.
- [15] Kettab A., Metiche R., Bennacar N., « De l'eau pour un développement durable : enjeux et stratégies », *Science de l'Eau*; vol. 21, n° 2, 2008, p. 247-256.
- [16] Catherine B., Alain H., Jean-M H., Technologies d'épuration en vue d'une réutilisation des eaux usées traitées (REUT) Rapport final, Convention de partenariat ONEMA-Cemagref, 2009.
- [17] Jean R., Tiercelin, Alain V., *Traité d'Irrigation*, 2^{ème} Edition TEC et DOC, Lavoisier, 2006
- [18] FAO., Irrigation avec les eaux usées traitées : Manuel d'utilisation, Bureau Régional pour le Proche Orient et l'Afrique du Nord, Caire Egypte, 2003.

TRANSFORMATION PHOTOCATALYTIQUE D'UNE MOLECULE PESTICIDEEN SOLUTION AQUEUSE

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Aujourd'hui, nous pouvons être sûrs que l'activité humaine et le mode de vie moderne sont responsables de l'aggravation de la pollution environnementale. Les sources de pollution sont de plus en plus nombreuses et diverses. Aussi, L'utilisation des pesticides dans différents domaines, leur caractère toxique et leur bioaccumulation constituent des dangers considérables pour l'homme. L'usage intensif de ces produits présente un impact significatif sur l'environnement et par conséquent sur les éléments de la chaîne alimentaire.

Des études ont montré la présence de résidus de pesticides dans les écosystèmes fréquemment en phase aqueuse. Ils sont aussi présents dans l'air et dans les aliments. Or, différentes études ont montrées les effets néfastes de ces produits sur la santé humaine, dépendant de la dose appliquée. Il apparaît donc nécessaire d'étudier le devenir et l'impact des pesticides dans l'environnement et particulièrement dans l'eau.

Actuellement, La photocatalyse hétérogène est un procédé qui se développe rapidement dans l'ingénierie environnementale. Cette technique de dépollution sort des laboratoires et fait son entrée dans plusieurs secteurs d'activité industrielle.

L'aspect très avantageux de cette méthode consiste en l'utilisation possible d'énergie solaire pour le traitement d'eaux. Jusqu'à présent, Le dioxyde de titane TiO_2 est le photocatalyseur le plus utilisé dans la dégradation des micropolluants organiques grâce à sa stabilité photochimique, son inertie chimique et biologique mais aussi son faible coût.

Dans ce travail, nous nous sommes intéressées à la dégradation d'un herbicide de la famille des pyridazinones par photocatalyse hétérogène (polluant /UV/ TiO_2 en suspension.) les analyses ont été réalisées par (HPLC). L'cinétique de dégradation et de minéralisation du polluant dépend des paramètres expérimentaux tels que la concentration en polluant, en TiO_2 et le temps d'irradiation. De même, il a été montré que les ions : Cl^- , SO_4^{2-} , NO_3^- , CO_3^{2-} présente un effet sur la dégradation photocatalytique. Sur la base des résultats obtenus, nous avons conclu que ce polluant disparaît totalement après 20 minutes d'irradiation. Le COT a été réduite à plus de 98%. L'analyse du mélange réactionnel par HPLC couplé à la masse nous a permis en outre d'identifier les photoproduits formés lors de la minéralisation.

Mots clés : Pollution- Pesticide – dégradation – photocatalyse – TiO_2

WASTEWATER COLORATION

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INTRODUCTION

Contamination of water resources, mainly in terms of quality, is a problem that is acute nowadays. It is the result of the massive use of organic and mineral pollutants from agricultural, urban and industrial domains.

The coloration of wastewater is one of the major problems faced by the wastewater treatment plants due to the toxicity of dyestuffs, their non-biodegradation and their resistance to conventional treatment processes.

RESULTS

This problem is reflected in the treatment plant chosen as an example, where the effluent is treated but the coloration remains and resists during all stages of processing treatment. The molecules suspected of being the source of coloration are non-biodegradable.

Since these dye molecules are unknown and their sources either, we did sampling in the station, then the activated carbon adsorption was carried out to try to recover these molecules by adding a 100g of activated carbon to 100ml of the sample and stirring for 30 minutes. A second stirring, after filtration and adding 50ml of methanol is done. And to ultimately eliminate the traces of water we used sodium sulfate. We tried to characterize the resulting product by different techniques for characterization and microanalysis. It was therefore, characterization by methods: HPLC coupled mass, column chromatography and TLC. The results thus found so were two predominant molecules, one of them is likely to have as a source the olive industry. And from NMR and Mass Spectroscopy we seek to identify them approximately.

As investigated, it was two principal molecules with wavelength $\lambda = 230$ nm and the other at $\lambda = 275$ nm, for which we have to specify the source and trying to eliminate them by an eco-process. To preserve and improve the quality of the water, conventional processing techniques have been already implemented. They involve multiple physicochemical processes such as adsorption on different types of solid materials, chemical oxidation, flocculation / coagulation and biodegradation. It is up to us to propose solutions that are efficient, economic and ecological for bleaching effluents while respecting the standards. Note that sampling will run for a year to specify the industry likely to be the source of the coloration, and then we should propose solutions from the source, that surely would be more effective.

KEYWORDS : *Wastewater coloration, dyes, adsorption, characterization technics*

Acknowledgement

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ADSORPTION OF METHYLENE BLUE FROM AQUEOUS SOLUTIONS ONTO DRIED AND CHEMICALLY MODIFIED BIOSORBENT

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Considering that food, cosmetics, pharmaceuticals and most importantly textile industry use dyes in order to color their products, then wastewater from these are loaded with dyes that cause serious problems to the environment. Many dyes and color effluents are toxic and have carcinogenic and mutagenic effects that influence environment and also human [1]. Hence, removal of synthetic dyes from wastewater is of concern nowadays.

Various physical, chemical and biological techniques have been introduced for the treatment of these effluents. These techniques are: coagulation-flocculation, membrane filtration, adsorption, oxidation and reduction [1].

Adsorption process is one of the most effective and economically feasible methods for the removal of dyes from aqueous solutions. Activated carbon is the most popular and widely used adsorbents in the treatment of gases and wastewater throughout the world [2], [3]. Moreover its high cost simulated research for other effective and cheaper adsorbents.

It is recommended that the applied adsorbent should be available in large quantities, easily regenerable, and cheap. The use of waste materials from agriculture and food industries as biosorbents has the dual advantage of waste reuse and low sorbent cost [4].

The purpose of this work is to evaluate adsorption capacity of a new adsorbent from fruit peels, by removal of methylene blue; this latter is used in dyeing in textile industry. In order to ameliorate the adsorption capacity, an other adsorbent was prepared by chemical modification of fruit peels.

Adsorption kinetics was modeled using pseudo-first-order and pseudo-second order models. Effect of adsorbent dose, solution pH, initial solution concentration and temperature was investigated. Thermodynamic parameters such as ΔH° , ΔS° and ΔG° were evaluated.

Keywords: Adsorption, Methylene Blue, Kinetics, Thermodynamic

References

- [1] Hedi Ben Mansour, Oualid Boughzala, dorra Dridi, Daniel Barillier, Leila Chekir-Ghedira et
Ridha Mosrati, Les colorants textiles sources de contamination de l'eau : Criblage de la toxicité et des méthodes de traitement, Journal of Water Science, vol. 24, n° 3, 2011, p. 209-238.
- [2] O.J. Hao, H. Kim, P.C. Chiang, Decolorization of wastewater, Crit. Rev. Env. Sci. Technol. 30 (2000) 449–505.
- [3] Juang R.S, F.C. Wu and R.L. Tseng, The ability of activated clay for the adsorption of dyes from aqueous solutions. Environ. Technol. 18, (1997), 525-531.
- [4] Amit Bhatnagar, Mika Sillanpää, Anna Witek-Krowiak, Agricultural waste peels as versatile biomass for water purification – A Review, Chemical Engineering Journal. 270 (2015) 244–271

EFFECTIVE REMOVAL OF HEAVY METALS FROM AQUEOUS SOLUTION BY SYNTHETIC BALL CLAY AS POTENTIAL LOW-COST ADSORBENT

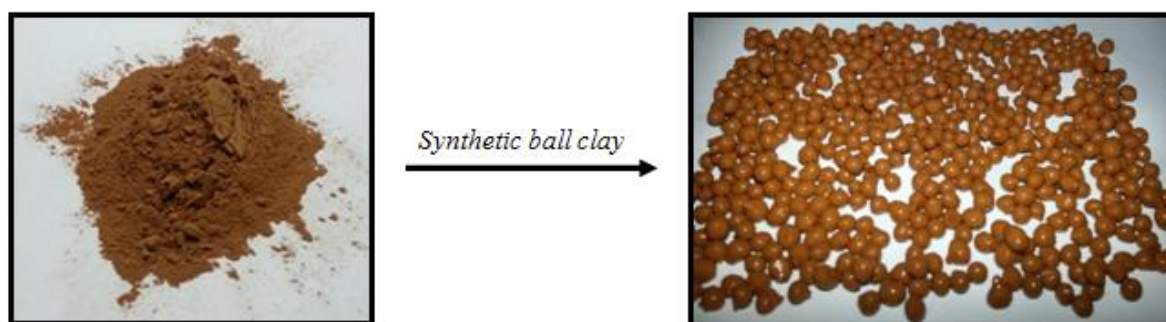
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Abstract

In our laboratory, the prepared adsorbent was characterized using FT-infrared spectroscopy (IR), thermogravimetric analysis (TGA), X-ray diffraction (XRD), specific surface area (BET), scanning electron microscopy (SEM), fluorescence X-ray and energy dispersive spectroscopy (EDS) techniques.



The effect of different operational parameters for enhanced heavy metals adsorption by ball clay was studied, such as: adsorbent mass, initial concentration of pollutant, influence of humic acid, temperature and pH. The empirical results showed that all these parameters have an impact on the removal of heavy metals (Pb^{2+} , Cd^{2+}) of industrial waste water. The equilibrium adsorption data obtained at 20°C were analyzed by Langmuir and Freundlich isotherm models.

The results showed that the synthesized ball clay sample is an efficient adsorbent for the adsorptive removal of industrial waste water heavy metals in aqueous medium.

Keywords: Ball clay, Heavy metals, Adsorption, Isotherms, Industrial waste water.

COMPARATIVE STUDY OF THE REMOVAL OF ACID GREEN1 DYE FROM AQUEOUS SOLUTION BY USING ADSORBENTS BASED ON NATURAL MOROCCAN Palygorskite CLAY AND ITS GRAFTED ORGANOMODIFIED

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The treatment of textile wastewater is usually achieved by a set of physicochemical processes. However, effluents quality does not meet the compulsory standards and their pouring in the nature arises a big pollution issue. Among many techniques used to remove toxic dyes from the wastewater, adsorption is considered as an efficient treatment process. Besides, when the adsorbents originate from natural resources, the treatment by adsorption becomes cheap eco-friendly process on one hand and a mean of raw materials valorization on the other hand.

In this respect, this study aims at comparing the adsorption potential of natural Moroccan palygorskite clay (Na-Pal) before and after its modification by grafting on its edges silanol sites with aminopropyltriethoxysilane (APTES) (APTES-Pal).

Both the adsorbents materials were first characterized by X-ray diffraction (XRD), Fourier-transform infrared (FTIR) spectroscopy and electrokinetic measurements (potential zeta assessments). Thereafter, batch experiments were carried out to investigate the effects of contact time, pH, adsorbent dose, and initial dye concentration on the adsorption behavior of the reactive AG 1 by both the adsorbents. The results showed that the optimum pH value for dye adsorption was 3.50 for both the samples, at which the adsorption capacities of the reactive AG 1 by Na-Pal and APTES-Pal at 298 K reach 89.60 and 131.57 mg/g, respectively. Adsorption equilibrium data obtained in both the cases were found to better correlate with Langmuir model. This result indicated that APTES-Pal provided specific homogeneous sites where monolayer dye adsorption occurred. Results issued from FTIR analyses of both the samples before and after the dye adsorption demonstrated that the adsorption mechanism was of electrostatic attraction type.

Key words: Clay, Palygorskite, Grafted palygorskite, Dye, Adsorption.

METHYLENE BLUE DEGRADATION IN WATER THROUGH A HETEROGENEOUS PROCESS CATALYZED BY NATURAL BENTONITE

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Dyes have become the most abundant pollutants in industrial wastewater, due to their wide utilization in several industries. Commercial wastewater treatment methods utilize the combination of biological, physical and chemical treatments. Biological treatment units tend to become very large due to the slowness of biological reactions. The physical methods only transfer waste components from one phase to another. Chemical treatment can result in the formation of toxic by-products [1].

Due to their excellent properties, clays have been widely used in several applications, particularly in catalysis. They require relatively mild conditions and they are available and inexpensive [2]. Bentonite (BT) is widely available in the northeast region of Morocco. Our objective is the valorization of this natural material in the heterogeneous degradation of dyes.

In present work, we present the oxidative degradation of methylene blue (MB) by the BT in the presence of hydrogen peroxide as clean oxidant. We try to get closer to terms the natural environment. The colorimetric method easily used in the field has been developed. Various parameters were studied on process performance; in particular, catalyst mass, initial concentration of H₂O₂ and MB concentration. Finally, the structure-activity relationship was also examined. The results indicate that BT as a natural and inexpensive material is a suitable catalyst for the degradation of MB and could also be applied to textile dyes.

KEYWORDS: Bentonite, Methylene blue, Hydrogen peroxide, Catalytic degradation.

REFERENCES

- [1]: R. Molinari, F. Pirillo, M. Falco, V. Loddob, L. Palmisano, Photocatalytic degradation of dyes by using a membrane reactor, *Journal of Chemical Engineering and Processing*, 43 (2004) 1103-1114.
- [2]: Z. Sun, Y. Chen, Q. Ke, Y. Yang, J. Yuan, Photocatalytic degradation of cationic azo dye by TiO₂/bentonite nanocomposite, *Journal of Photochemistry and Photobiology A: Chemistry*, 149 (2002) 169-174.

ADVANCED TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT

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The overarching goal for the future of reclamation and re-use of water is to capture water directly from non-traditional sources such as industrial or municipal waste-waters and restore it. Because of the vast use of organic chemicals in modern society, almost any wastewater stream from industrial processes or households contains such compounds and disposal without proper treatment will therefore result in exposure to humans and the environment.

The recent patents applicable for water and wastewater treatment addresses improvement for ease of operation, reliability, cost, size, maintainability, improved water quality, and analytical methods. There are also patents that show applications of nano- technology especially in the areas of disinfection, ion exchange, and detection methods. With the increasing demand for drinking water and requirements for improved quality, more strict regulations for effluent discharge limits, and environmental awareness for water quality impacts, the research and development in water and wastewater technologies will increase in the coming years. The majority of the recent patents address the improvements for current technologies such as filtration and disinfection.

The recent trends indicate that there will be new requirements to monitor and perhaps regulate the emerging groups of contaminants which are not currently regulated (i.e., micro constituents which originate from over the counter drugs entering wastewater systems). The adverse effects of pharmaceuticals in the environment include aquatic toxicity, development of resistance in pathogenic bacteria, genotoxicity and endocrine disruption. With the advancements in materials science, nanotechnology, and information technology; it is likely that there will be new developments in the area of membranes filtration, disinfection/oxidation methods, ion exchange resins, sorption technologies, as well as water and wastewater management methods utilizing information and telecommunication technologies with remote monitoring and control capabilities.

KEYWORDS: Nanotechnology, Membrane technology, Disinfection/oxidation, Pharmaceuticals removal.

KINETIC STUDY OF NITRATE REMOVAL ON BIPOLAR BDD ELECTRODE

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INTRODUCTION

Nitrate electro-reduction is an extremely complex process because of the production of ammonia and nitrite as unfavorable by-products [1]. However, many anode materials are tested and found effective for nitrite and ammonia oxidation to nitrogen gaseous and nitrate such as DSA (O₂-Dimensionally Stable Anodes) and BDD (Boron-Doped Diamond) anodes [2,3]. But until now, the mechanisms are not clear for nitrate elimination. The main objective of this work was to study the cathodic reduction of nitrate and the simultaneous anodic oxidation of electrogenerated by-products (ammonia and nitrite) in a bipolar BDD cell. The effect of chloride on kinetic rates is also undertaken in order to propose a nitrate removal mechanism.

MAIN RESULTS

In order to analyze the effect of chlorides ions on the kinetic of nitrate removal and indirect nitrite and ammonia oxidation on bipolar BDD electrode, a series of experiments were performed. At the beginning, two concentrations of nitrate solution were selected (4.6 and 35.7 mmol L⁻¹). One series was performed without addition of NaCl, however, second and third series were carried out by adding 500 and 1000 mg L⁻¹ of NaCl, respectively.

Without chloride medium (Figure 1 (a)), more than 90% of the initial nitrate was reduced only after 2h of electrolysis to give as final product N₂ (93%), a small amount of NH₃ (7%) and traces of NO₂⁻ (0%). To study the reaction rates of nitrate removal on BDD electrode, elementary steps are taken into consideration. Nitrate reduction, by-products oxidation and nitrogen gaseous production are often followed a pseudo-first kinetic order according to following equations [2]:

$$\begin{aligned} -\frac{d[NO_3^-]}{dt} &= (k_1 + k_2 + k_3)[NO_3^-] - k_1[NO_2^-] \\ \frac{d[NO_2^-]}{dt} &= k_1[NO_3^-] - (k_1 + k_4 + k_5)[NO_2^-] \\ \frac{d[NH_3]}{dt} &= k_2[NO_3^-] + k_4[NO_2^-] - k_6[NH_3] \\ \frac{d[N_2]}{dt} &= \frac{1}{2} \{k_3[NO_3^-] + k_5[NO_2^-] + k_6[NH_3]\} \end{aligned}$$

The values of the corresponding kinetic constants were estimated from the fitting of the experimental data to the mathematical model using Matlab Software. The obtained goodness-of-fit was evaluated by two metrics, the highest correlation coefficient (R²) and the lowest residual error (Rot Mean Square Error, RMSE).

Results show that nitrate reduction reactions took place for giving NO₂⁻, NH₃ and N₂ the estimated kinetic constant values are 5.4 × 10⁻⁴, 1.7 × 10⁻⁵ and 1.7 × 10⁻⁹ s⁻¹, respectively. Moreover, the highest kinetic constant was obtained for nitrite reduction for giving nitrogen gaseous with a value of 4.7 × 10⁻³ s⁻¹.

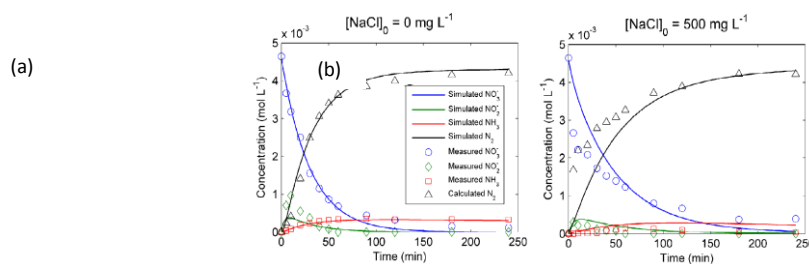


Figure 4. Change of the concentration of nitrogenous compounds with the experimental time for feed solutions containing nitrite (4.6 mmol L^{-1}) and initial chloride concentrations of: (a) 0 and (b) 500 mg L^{-1} .

Figure 5.

The process is limited by mass transfer and some reactions are favored compared to others that are why an increase of initial nitrate concentration can made a modification on the kinetic rates [4,5]. In our case the increase of initial nitrate concentration from 4.6 to 35.7 mmol L^{-1} leads to the enhancement of some reactions against others. By adding chloride ions (Figure 1 (b)), the oxidation of hypochlorous species on BDD anode by means of hydroxyl radicals was also taken into consideration. As well as, the intervention of those active species on indirect by-products oxidation and kinetic rates are expressed as follows:

$$\begin{aligned}
 -\frac{d[\text{NO}_3^-]}{dt} &= (k_1 + k_2 + k_3)[\text{NO}_3^-] - (k_1 + k_7)[\text{NO}_2^-] - k_8[\text{NH}_3] & \frac{d[\text{NO}_2^-]}{dt} &= k_1[\text{NO}_3^-] - (k_1 + k_7 + k_4 + k_5)[\text{NO}_2^-] \\
 \frac{d[\text{NH}_3]}{dt} &= k_2[\text{NO}_3^-] + k_4[\text{NO}_2^-] - (k_6 + k_8 + k_9)[\text{NH}_3] \\
 \frac{d[\text{N}_2]}{dt} &= \frac{1}{2} \{k_3[\text{NO}_3^-] + k_5[\text{NO}_2^-] + (k_6 + k_9)[\text{NH}_3]\}
 \end{aligned}$$

It was noted that the formed amount of nitrite and ammonia during electrolysis was less than that formed in the absence of chloride ions. Otherwise, a simultaneously increase of initial nitrate and chloride concentrations were accompanied by a slightly decrease of kinetic constant values corresponding to indirect oxidation by hypochlorite ions; this is due to the presence of other competitive reactions.

References

- [19] Engracia Lacasa et al., Journal of Hazardous Materials, vol. 213–214, 2012, pp. 478-484
- [20] Pérez G. et al, Chemical Engineering Journal, vol. 197, 2012, pp.475-482
- [21] Mouna Ghazouani et al., Desalination and Water Treatment, vol.54, 2015, pp.1107-1117
- [22] Rajkumar Patil, Vinay Juvekar, Chemical Engineering Science, vol.110, 2014, pp. 72-82
- [23] Kodým R. et al., Journal of Applied Electrochemistry, vol.37, 207, pp.1303-1312.

KINETIC MODELLING AND MECHANISM OF DYES ADSORPTION ONTO RAW AND ACTIVATED EUCALYPTUS SAWDUST SAMPLES

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INTRODUCTION

The effluents from dye industries are highly coloured coupled with high chemical and biochemical oxygen demands [1]. Several methods have been employed to remove dyes from the wastewater such as adsorption which is an economically feasible process. In Morocco, eucalyptus sawdust is mainly used as fuel. It would be interesting, as revealed by this work, to valorize the use of sawdust as adsorbent and as activated carbon. This later has been synthesized by physical activation method which involves carbonization of the raw material. In this work, the preparation and characterization of activated carbons from eucalyptus sawdust were reported and the adsorption equilibrium of two dyes which are Methylene blue (MB) and methyl orange (MO) onto raw (RES) and activated eucalyptus sawdust (SAC) were evaluated, a commercial activated carbon (CAC) was used as reference.

MAIN RESULTS

The results of BET analysis shows that the surface area of the carbonized sawdust is in order of 309.2 m²/g, whereas activated is 645.7 m²/g. The analysis by infrared spectroscopy revealed that functional groups (e.g., amine, hydroxyl and carboxyl) on Eucalyptus Sawdust would be the active binding sites for the adsorption of the studied dyes. The analysis shows that the functional groups responsible for adsorption are present in the RES and its activated carbon but not in the Eucalyptus Sawdust Carbon.

The optimum conditions for the adsorption of dyes onto RES and SAC was determined using Statistical Experimental Design. The comparison of the adsorption capacities show the importance of activated process. The SAC is more efficient than the RES for the elimination of both dyes. This would be assigned to the molecular structure modified after activation. We also observe that the MB retention rate of SAC is almost equivalent to the CAC after 30 minutes stirring time. Moreover, for the MO the retention rate of SAC exceed that of CAC (fig.2).

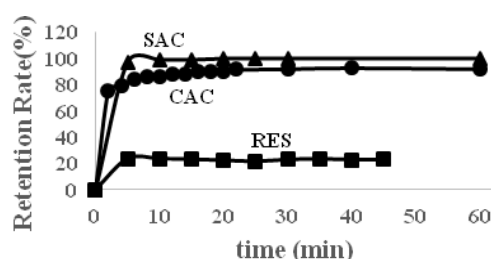


Figure 1: Adsorption kinetics of MO onto RES, SAC and CAC

The study of kinetic models shows clearly that the pseudo-second order kinetic is the most suitable model that can describe this adsorption.

From isotherms study, the calculated dimensionless equilibrium parameter (R_L) values were greater than 0 but less than 1 indicating that Langmuir isotherm is favorable, indicating monolayer adsorption on a homogenous surface, It is stated from Freundlich model that the exponent was $1 < n_f < 10$, indicating that the sorption of dyes onto SAC is favorable [2].

CONCLUSION

The results of the present study demonstrate that Raw Eucalyptus Sawdust (RES) an abundant agricultural waste and its activated carbon can be used effectively as adsorbent for removal of dyes in aqueous solutions.

KEYWORDS

Sawdust Activated Carbon (SAC), Raw Eucalyptus Sawdust (RES), Eucalyptus Sawdust Char (ESC), adsorption isotherm, kinetic models.

Acknowledgement

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References

- [1] Hebeish A et al., Clean Techn Environ Policy, vol. 13, 2011, pp. 713-718.
- [2] S. Goldberg, Equations and Models Describing Adsorption Processes in Soils. Soil Science Society of America, 677 S. Segoe Road, Madison, WI 53711, USA. Chemical Processes in Soils. SSSA Book Series, (2005) no. 8.

REMOVAL OF AN AZO DYE FROM WASTEWATER BY ADSORPTION USING LOW-COST NATURAL MOROCCAN PHOSPHATE (MPR) AS A NEW ADSORBENT

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Introduction

A dyeing plant consumes an enormous amount of water, ranging from several thousands to over 10,000 m³ per day. As a result, effluents from the textile industries are complex to treat because they contain important varieties of synthetic organic dyes, especially azo dyes which are found in discharges since their fixation rate on textiles remains below 60%. These are known to be toxic at low concentrations and, therefore, can cause significant harm to both flora and fauna. In general, azo dyes cannot be biodegraded in conventional biological wastewater treatment processes. Thus, various chemical and physical processes have been proposed, such as chemical coagulation, advanced oxidation, activated carbon adsorption, or electrocoagulation and membrane processes (Chang et al., 2010; Deng et al., 2015; Orozco et al. 2009; Yao et al., 2013). All these techniques present significant disadvantages, such as high-energy requirements, production of large quantities of sludge, membrane fouling. If a physicochemical treatment based on adsorption using activated carbon is a possible alternative, this process remains expensive due to the cost of the adsorbent and the difficulty of its regeneration. As a result, adsorption process using effective and inexpensive natural adsorbents emerges as one of the most promising and low-cost method for treating textile wastewater. Taking into account their availability and cost, natural Moroccan phosphate rock (MPR) constitutes a possible alternative adsorbent that could be used for the removal of dyes from textile wastewater.

Materials and methods

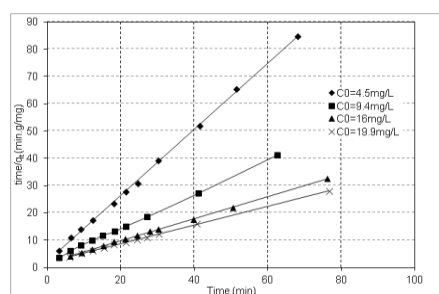
In the present study, natural MPR was used as a new adsorbent for the removal of dyes from wastewater. Firstly, the MPR was characterized by different techniques, namely: Scanning Electron Microscopy, FTIR spectroscopy, thermogravimetry (TGA) and BET surface area measurement. The MPR samples were first washed several times with distilled water to remove the impurities and fine particles, dried for 48h at 60°C, and then stored in glass jars. Astrazon Orange G dye (AOG) was used as a typical cationic azo dye of industrial textile wastewater. The experiments were carried out both in batch and continuous fixed-bed adsorption under different operating conditions, such as liquid flow rates, initial AOG concentrations, initial pH, mass of adsorbent and temperature. The Concentration of OG was measured using a UV/Vis spectrophotometer Specord 250 Plus (Analytik Jena AG, Germany). The continuous flow adsorption breakthrough experiments were performed using different fixed-bed columns.

Results

First, MPR was shown to exhibit a low surface area (18 g/m^2), but also to remove dyes efficiently (from 47.5% to 98.8% depending on initial AOG concentration). Experimental data in batch conditions show that the AOG adsorption isotherm on MPR can be represented by a Langmuir model (see Table 1), whereas adsorption kinetics follows a pseudo-second-order model (see Figure 1). The experimental thermodynamic data revealed that the physisorption was the main mechanism responsible for AOG removal. A parametric analysis was carried out to study the influence of different variable on the breakthrough profile. Thomas, Adams-Bohart, Yoon-Nelson, Wang and dose response models were tested to predict the breakthrough curves and to estimate the characteristics parameters of the columns dynamics. Experimental data was adequately fitted by Thomas and Yoon-Nelson models, whereas the Adams-Bohart model poorly described the performance of fixed-bed columns.

Table 1: Parameters of Langmuir model (Morocco) Figure 1. Characteristic plot of the second order model

Temperature (°C)	q_{max} (mg/g)	K_L (L/mg)	R^2
20.2	4.129	0.072	0.999
25.0	4.838	0.090	0.988
30.0	4.454	0.156	0.997
34.8	3.774	0.196	0.997
40.2	3.846	0.260	0.997



Conclusion

The kinetics and adsorption isotherms of AOG onto MPR were investigated. Langmuir adsorption isotherm and pseudo-second order kinetic models were found to describe batch adsorption data. Thermodynamic studies showed that the adsorption mechanism was a physical reversible process, slightly endothermic, spontaneous and under entropic control. This data was useful to simulate continuous adsorption experiments that were adequately fitted by Thomas and Yoon-Nelson models.

References

- Chang, M.-W., Chung, C.-C., Chern, J.-M., Chen, T.-S., 2010. Chem. Eng. Sci. 65, 135-140.
- Deng, Z., Fung, K.Y., Ng, K., Wei, C., 2015. Chem. Eng. Sci., <http://dx.doi.org/10.1016/j.ces.2015.09.029>.
- Orozco, S.L., Arancibia-Bulnes, C.A., Suárez-Parra, R., 2009. Chem. Eng. Sci. 64, 2173-2185.
- Yao, Y., Wang, L., Zhu, S., Huang, Z., Wangyanglu, Y. M., 2013. Chem. Eng. Sci. 101, 424-431.

DEGRADATION OF A BENZOIC ACID AND ITS DERIVATIVES BY ELECTRO-FENTON/BDD PROCESS: OPTIMIZATION USING RESPONSE SURFACE METHODOLOGY (RSM) BASED ON THE CENTRAL COMPOSITE DESIGN (CCD)

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Waste waters contain numerous organic micro-pollutants of anthropogenic origin, whose behavior and fate are of primordial importance for the protection of the environment. In recent years, various technologies have been developed for environmental pollutants remediation. Among them, advanced oxidation processes (AOPs) have received great attention for removal of hazardous organic pollutants from contaminated water [1]. Among AOPs, oxidation with electrochemical and Fenton's reagent has been considered to be a promising and attractive treatment technology for degradation and decolorization of wastewaters. In recent years there has been an increased focus on the use of electrochemical methods which can produce OH• as the main oxidizing agent by different ways. [2]

In the present study, the benzoic acid was degraded by the electro-Fenton process, using a BDD electrode as cathode for H₂O₂ production. The independent parameters of applied current, dye and Fe²⁺ concentrations and electrolysis time were evaluated. Experimental data were optimized by means the Response Surface Methodology (RSM) with a five-level full-factorial central composite design (CCD) based. The ANOVA analysis confirmed that all of the variables have significant influence on the model response and showed a high coefficient of determination value ($R^2 = 0.978$). The optimum values of the process variables for the maximum degradation efficiency (88,8 %) were Fe²⁺ concentration = 0.03 mM, applied current = 300 mA, RY17 concentration = $2 \cdot 10^{-4}$ M and electrolysis time = 30 min. Under the experimental conditions previously determined, the degradation of the phthalic acid and the two polycarboxylic (trimellitic (Tri) and pyromellitic (Pyro)) acids has been investigated. The comparison of the oxidation efficiency of the benzoic acid and its derivatives by the electro-Fenton process was undertaken.

KEYWORDS: Benzoic acid and its derivatives; Advanced Oxidation Processes; Electro-Fenton; Response Surface Methodology (RSM); Central composite design (CCD).

REFERENCES:

- [1]. A. R. Khataee, M. Zarei, S. K. Asl, Journal of Electroanalytical Chemistry 648 (2010) 143.
- [2]. S. Mohajeri, A. Hamidi, M. H. Isa, M. A. Zahed, M. N. Adlan, Journal of Hazardous Materials 176 (2010) 749.

THERMO-PHYSICAL VALORIZATION OF SLUDGE FROM THE WASTEWATER TREATMENT PLANT IN MARRAKECH BY CONVECTIVE SOLAR DRYING

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Drying the sewage sludge is an intermediate stage of all the possibilities of disposal or valorization in the main processes used in the present-day wastewater treatment plants. Understanding the phenomenon that happens during drying process is based on a deep knowledge of equilibrium between air and product and mastery of the drying kinetics and transformations of the product.

Solar drying has become a best solution suited for sludge dehydration in treatment plants with average capacities of less than 100000 population equivalent. This alternative to classical thermal drying process is used to respond to the needs of communities in regulatory compliance.

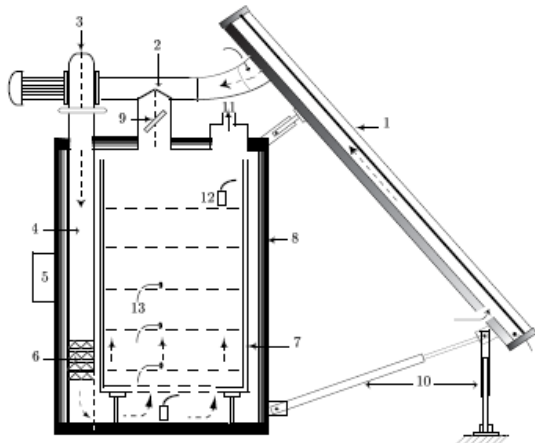
The drying kinetics depends on the heat and mass transfers at the interface between air and the product within which the two previous exchanges are transferred. The mechanisms of these transfers are very complex besides they are coupled. The reason for the complexity of the transfer mechanism is due to the heat and mass transfer coefficients added thermo-physical properties which are strongly related to the temperature θ and the moisture content X of the product.

A deep knowledge of heat transfer parameters, mass, diffusion and the drying behavior of the product are considered indispensable for the conceptualization, simulation and optimization of the drying process. It is then necessary to have an accurate model that can predict rates of elimination of water and describe the drying of the product.

In this work, we determine experimentally the sludge drying kinetics by an experimental macroscopic approach involving the determination of sludge drying behavior during their drying under controlled conditions of temperature and air flow rate using an indirect forced convection solar dryer which is installed in the Laboratory of Solar Energy and the Aromatic and Medicinal Plants of Teacher's Training College in Marrakesh. The experimental results were exploited for determining a drying Characteristic Curve and the rate of drying followed by an analysis of temperature influence on this rate. The experimental curves of drying obtained were approximated by nine mathematical models that exist in the literature.

The experimental apparatus used to study the drying of sewage sludge is an indirect forced convection solar dryer (fig. 1). The dryer is the type "cupboard" with polyvalent shelves and enable total or partial recycling of drying air. This dryer allows producing a hot air flow rate with aero-thermal characteristic (temperature, air flow, relative humidity).

KEYWORDS: Solar convective; Drying kinetics; Sludge; treatment; Characteristic drying curve.



(1) solar collector, (2) ventilation duct, (3) fan, (4) suction line, (5) control box, (6) power supply, (7) floors, (8) drying cabinet, (9) air valve, (10) air inlet, (11) air outlet, (12) humidity probe, (13) thermocouple.

Fig.1. Convective solar dryer installed in Marrakech (ENS)

AN EVALUATION OF THE EFFECTS OF WASTEWATER REUSE ON THE PRODUCTION OF ALFALFA (*MEDICAGO SATIVA*)

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The shortage of water resources has become an important issue for agriculture of Morocco. The use of wastewater for irrigation has now become a reality rather than a matter of choice. The aim of this study is to evaluate the effects of untreated and treated wastewater in comparison with well water, on the soil and crop. The experiment was conducted in a wastewater treatment plant in Tidili, Morocco. The municipal wastewater is treated with constructed wetland system, where a land area of 75 m² was arranged to install three plots (P1, P2, P3), plot dimensions are 1 × 1 m. Each plot is divided into 4 rows planted with the same variety of alfalfa (*Medicago sativa L.*) with a density of 20seeds/m² with two repetitions for each plot. Equal amount of well water (the control), untreated and treated wastewater was applied using surface irrigation method. The sampling was done once a week over a five-month period from March to July 2015. Physical and chemical parameters in the soil, untreated and treated wastewater were analyzed. The biomass (total fresh weight, total dry weight of the plants) was used as an indicator of the plant yields. Agro-physiological parameters were also assessed.

Biomass of *Medicago sativa L.* grown in plots irrigated with wastewater was higher than those grown in plots irrigated with well water. These results indicate the ability of wastewater supplying the necessary nutrients for plant growth. The use of the domestic wastewater has shown improvement in the physicochemical properties of the soil, yield along with the nutrient status as compared to the application of groundwater. The results showed better crop growth with increased fertility status of the soil. The findings give applicable advice to commercial farmers and agricultural researchers for proper management and use of treated domestic wastewater for agricultural purpose.

KEYWORDS: Alfalfa; growth; Irrigation; Wastewater treatment; Water reuse

Acknowledgement: The authors would like to thank the National Centre for Research and Study on Water and Energy (CNEREE), Cadi Ayyad University; the Laboratory of Hydrobiology, Ecotoxicology and Sanitation (LHEA, URAC 33), Cadi Ayyad University; and the Pole of Competences on Water and Environment (PC2E) for their technical support of this research.

**COMPARATIVE STUDY OF THE HYDRODYNAMIC AND
MECHANICAL PERFORMANCE OF SEMIPERMEABLE
MEMBRANES SYNTHESIZED BASED ORGANIC POLYMERS.
APPLICATION OF ULTRAFILTRATION OF WASTE WATER
LOADED WITH MODELS INDIGOID DYE**

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In recent years, the operating techniques of decontamination of industrial effluents by membrane processes has been an important development compared to other conventional techniques, at the preservation of the environment, and it can return to their performance energy and technical-economic. Ultrafiltration(UF) is a membrane separation process in which the force transfer is a simple pressure gradient. These porous membranes have average pore sizes between 2 and 100nm, and they can be organic, inorganic and composite. Organic membranes are generally obtained from organic polymers by the technique of phase inversion, we have exploited in this present study, synthesizing asymmetric permeable membranes and/or semi-permeable membranes for ultrafiltration wastewater loaded with templates indigoid dye used for dyeing cotton fabrics. They are obtained according to the ternary phase diagram **polymer-solvent-non-solvent**, using 12% of polymer and 88% of the solvent [1].

The first membrane was made of **12%** polysulfone (PSU UDEL P1700) [1] and the other membranes were synthesized percentages **10/2 (%)** physical copolymers respectively namely, polysulfone/expanded polystyrene (PSe) [2], polysulfone/polyvinyl chloride (PVC) [3] and polysulfone/polyetherimide (PEI) [4]. The results of the hydrodynamic and mechanical characterization of harvested membranes and ultrafiltration water colored by indigo have shown that membranes composed of couples PSU/PSe and PSU/PVC having excellent hydrodynamic and mechanical properties, as well as the values of the fading rate were recorded respectively in percentages **80.36%**, **85.36%**, **87.24%** and **89%** vis-a-vis the membranes made of polysulfone, polysulfone/polyetherimide, polysulfone/expanded polystyrene and polysulfone/polyvinyl chloride.

KEYWORDS: Textile dye; Membranes; Ultrafiltration; Organic polymers; Discoloration.

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REFERENCES:

- [1]: M. Berradi, A. Essamri, A. El Harfi, J. Mater. Environ. Sci. 7(4) (2016) 1098-1106
- [2]: M. Berradi, A. El Harfi, Inter. J. Adv. Chem.2 (2) (2014) 62-65
- [3]: M. Allaoui, M. Berradi, M. El Hassan, M. Saadallah, A. El Harfi, Mor. J. Chem. 4 (1) (2016) 251-258
- [4]: S. Benkhaya, A. El Harfi, Inter. J. Innov. Appl. Stud. 10 (1) (2015) 285-294

TREATMENT OF RBBR IN AQUEOUS SOLUTION BY ZN-AL LAYERED DOUBLE HYDROXIDES: EQUILIBRIUM AND KINETIC STUDIES

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Many industrial discharge effluents containing high concentrations of dye are a visual and chemical pollution that must be treated prior to discharge of such waters downstream industries, it's the case of the textile industries, paper industries, plastics, leather industries, food industries, etc.

In the textile industry in particular, the wastewater is one of the largest sources of pollution of surface water and groundwater. These releases are enormous harm to human health and the environment. In fact, the different colors used cause serious problems because of their stability and their low biodegradability. Therefore, the remediation of contaminated by these chemicals is necessary both for environmental protection and for possible re-use of these non-conventional waters.

The treatment of colored water was the subject of several studies to reduce the intensity of the color and the organic matter contained in these waters. Adsorption techniques appear to be effective ways to eliminate lower-cost dye and prevent the regeneration of sludge. Among the adsorbents employees, layered double hydroxides (LDH) are promising especially for fixing dyes. Indeed, LDH have certain unique physical and chemical properties justify their environment application, such as their high anion exchange capacity and high charge density of the sheets that favor the intercalation of the anionic pollutants.

In this work, we focused on eliminating remazol brilliant blue R dye (RBBR) often used in Moroccan textile industry, in aqueous solution, by [Zn₂-Al-Cl] LDH. This material is inert and has a relatively low cost. The LDH compound was synthesized by coprecipitation method at constant pH 9 as a metal ratio Zn/Al = 2 and a ripening time of 72 hours under mild agitation.

The retention capacity depends on the initial pH of the solution. When pH is greater than 9 or less than 6, there is a decrease in the amount retained respectively due to contamination with the carbonate ions and the partial dissolution of the matrix. However maximum retention is obtained with an optimum pH of 6.4 which is also the pH of natural water.

The adsorption kinetics are well described by the kinetic model of pseudo-second order. This model assumes that the limiting step adsorption is the chemisorption which involves electrostatic interactions at the solid-liquid interface. To investigate the contribution of intra-particle behavior on the adsorption process, we traced the retention capacity according to the square root of time (Weber and Morris). The existence of two or three linear portions confirms the importance of the double layer on the adsorption, leading to the predominance of outreach on the intra-particle diffusion. Thus, this final phase can exist rather, to high concentrations of dye, which is proved by intercalation of the dye between LDH sheets.

The study of adsorption isotherms reveals that the adsorption equilibrium follows the Langmuir isotherm and the amount adsorbed of the textile dye depends on the mass of adsorbent used.

The results of different analytical techniques (XRD, IR, SEM and TGA) confirmed that the retention of the textile dye RBBR is governed by adsorption on the surface of the matrix LDH (mass ratio RBBR/LDH<2.7) and intercalation between the sheets via an exchange reaction of chloride anion by dye anion (RBBR/LDH>2.7). In the latter case the interlamellar distance becomes 0.778 nm to 0.952 nm with a horizontal arrangement of the dye compared to LDH sheets.

The removal of dye in anionic form by LDH gave satisfactory results. The material could be a good candidate for trapping such pollutants. Under optimum conditions, the retention is total (100%) when the mass ratio dye/LDH is between 0,2 and 0,4. Retention capacity reached 500 mg/g.

Keywords: Layered double hydroxide, Dyes, Kinetic study, Isotherms, Equilibrium, Retention.

ADSORPTION AND PHOTOCATALYTIC DEGRADATION OF INDIGO CARMINE DYE IN AQUEOUS SOLUTIONS

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The dyes are the organic compounds used in many industries: paper mills, cosmetics, agri-food, textiles, pharmaceuticals, as well as in medical diagnostic [1.2]. The annual production is 700 000 tonnes including 140 000 tonnes released in the Effluent [3]. Their elimination represents one of the main problems in the process of treatment of liquid releases. Several types are very toxic and hardly biodegradable [4.5]. The chemical complexity and the diversity of dyes make the treatments so-called "traditional" insufficient to be effective. Advanced oxidation processes (POA) are in full development at the present time for the degradation of organic molecules recalcitrant [6.7]

The heterogeneous photocatalysis in the presence of TiO₂, among these POA, is gradually emerging as a promising alternative for the elimination of these organic compounds soluble. The use of this technique leads to the complete mineralization of these pollutants in carbon dioxide gas, water and mineral acids at ambient temperature and atmospheric pressure [8.9].

In our work, we are interested to the adsorption and degradation of the dye Indigo carmine derived from indigoïdes dyes in aqueous media by heterogeneous photocatalysis.

The semi-conductor used is the titanium dioxide TiO₂ "600°C" prepared in our laboratory and it's compared to other commercial catalysts. The degradation experiments of this pollutant have been carried out in order to evaluate the physical-chemical factors that affect the kinetics of degradation. We also studied the effect of some inorganic ions and hydrogen peroxide on the initial speed of the disappearance of the dye.

KEYWORDS: advanced oxidation processes (POA), heterogeneous photocatalysis, adsorption, photodegradation, semi-conductor (TiO₂), indigo carmine dye.

REFERENCES:

1. Dogan, M., Alkan, M., *Chemosphere* 50 (2003) 517-528.
2. Annadurai, G., Juang, R. S., Lee, D. J., *J. Hazard. Mater.* 92 (2002) 263-274.
3. Messina, P. V., Schulz, P. C., *J. Colloid Interface Sci.* 299 (2006) 305-320.
4. Jenkins C. L., *Arch. Environ. Health* 40 (1978) 7-12.
5. Damodar, R. A., Jagannathan, K., Swaminathan, T., *Sol. Energy* 81 (2007) 1-7.
6. Rizzo, L., Meric, S., Kassinos, D., Guida, M., Russo, F., Belgiorno, V., *Water Res.* 43 (2009) 979-988.

MOLECULAR AND ENZYMATIC CHARACTERIZATION OF YEASTS ISOLATED FROM ACTIVATED SLUDGE ACCLIMATED TO WASTEWATERS OF OLIVE CANNINGFACTORY

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Introduction

Wastewaters from food processing industry, particularly those of olive canning factory cause real problems of pollution due to their complexity, their variability in time and the lack of efficiency treatment methods. Currently, the process of purification by activated sludge is the most widespread in wastewater treatment field. In such a method, bacteria are reported to be the main microorganism responsible of purification. However others' microorganisms such as yeasts have significant capacities in wastewater treatment. Thus, this work aims to study the diversity and role of yeasts during the acclimatization of activated sludge to olive canning factory wastewaters.

Mains results

Results showed a variation of yeasts load during the acclimatization experiment and this variation is function of effluent rates injected. The highest yeast load (4.63 Log₁₀ CFU/ml) is obtained with 80% of effluent and lowest (2.1 Log₁₀ CFU/ml) to 20% of effluent. Identification of yeasts isolated throughout the acclimatization allowed observing 8 different profiles among which 2 were identified as *Candida tropicalis* and *Kluyveromyces fragilis*. Moreover, 83.5% of isolates showed amylase activities and 11% possessed lipase activities.

Conclusion

C. tropicalis and *K. fragilis* have been identified on 8 profiles observed. The majority of yeasts have an amylase activity and to a lesser extent a lipase activity. These activities are essential for wastewater treatment.

Keywords: acclimatization, activated sludge, Wastewaters, yeasts

THE STUDY OF THE PHOTOCATALYTIC DECOMPOSITION OF METHYL ORANGE IN THE PRESENCE OF DOPED TiO₂ NANOPARTICLES

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INTRODUCTION

The dyes are organic compounds used in many industries [1]. Their removal causes a major problem in the liquid waste treatment process [2]. Treatment with photocatalysis is a promising alternative for the disposal of the latter. The objective of this work is to study the adsorption and photodegradation of methyl orange dye in an aqueous medium in the presence of TiO₂ Sachtopore nanoparticles, in a pure and doped state with different percentages Chloride of Zinc (ZnCl₂) and sulfate nickel II (NiSO₄), synthesized by the coprecipitation method. Different catalysts of TiO₂ are used to compare their efficiencies; TiO₂ P25 was used as a reference.

MAIN RESULTS

The adsorption on the catalyst surface is an initial and essential step for the photocatalytic reaction [3,4]. In order to identify the optimal conditions of the degradation of our dye, we first started with the study of its adsorption on different TiO₂ catalysts. The curves of adsorption kinetics show that regardless of the catalyst, the adsorbed amount increases with the increase of the agitation time to tend towards a limit value corresponding to the maximum adsorbed amount after about 40 minutes. The curves in this figure show that under the same conditions, the dye does not have the same affinity concerning the solid. The dye adsorbs better on the nanoparticles of doped TiO₂ than the pure TiO₂. In addition, the adsorption capacity depends on the nature and amount of dopant. The amounts of the dye adsorbed on the six catalysts equilibrium varies in the following order: doped TiO₂Sachtopore (ZnCl₂/TiO₂ = 0,2%) >doped TiO₂Sachtopore (ZnCl₂ /TiO₂ = 0,1%) >doped TiO₂Sachtopore (NiSO₄/TiO₂ =0,2%)>doped TiO₂Sachtopore (NiSO₄/TiO₂ = 0,1%) > TiO₂ Sachtopore pure> TiO₂ P25. This improvement in the results can be justified by the increase of the adsorption sites of the catalyst or it is probably due to the structure of each catalyst [5].

In the 2nd part, we will study and compare, the degradation by photocatalysis, methyl orange, on different semiconductor, to evaluate the efficiency of the catalyst on the degradation kinetics of methyl orange (Fig 1). It is noted that the characterization of these solids has been made in details in the rest of our work as well as the influence of some parameters on the degradation.

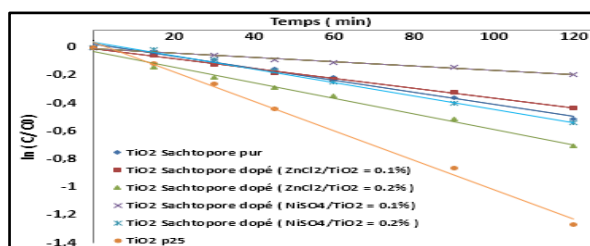


Figure 1: Plot of $\ln(C/C_0)$ versus irradiation time of MeO (5ppm) in the presence of TiO₂ Sachtopore pure and doped (1g/L).

The curves $\ln(C/C_0) = f(t)$ show that under the same conditions, this dye does not exhibit the same affinity concerning the solid. The photocatalytic degradation efficiency of the four catalysts at equilibrium vary in the following descending order: TiO_2 P25 > TiO_2 Sachtopore doped ($\text{ZnCl}_2/\text{TiO}_2 = 0,2\%$) > doped TiO_2 Sachtopore ($\text{NiSO}_4/\text{TiO}_2 = 0,2\%$) > Pure TiO_2 Sachtopore > TiO_2 Sachtopore doped ($\text{ZnCl}_2/\text{TiO}_2 = 0,1\%$) > doped TiO_2 Sachtopore ($\text{NiSO}_4/\text{TiO}_2 = 0,1\%$).

So doping improves the photo-reactivity of TiO_2 Sachtopore. Zinc gives better results than nickel with a mass percentage of 0,2%. A mass percentage of 0,1% by Zn or Ni does not improve the photocatalytic nature of TiO_2 Sachtopore.

CONCLUSION

All the results obtained in this work allow the following conclusions:

- Doping improves the photoreactivity of TiO_2 Sachtopore. Zinc gives better results than the nickel but with a percentage of 0,2%.
- All degradation kinetics are in the first order.

References

- [1]. Messina, P. V., Schulz, P. C., J. Colloid Interface Sci, vol. 299, 2006, pp. 305-320.
- [2]. Damodar, R. A., Jagannathan, K., Swaminathan, T., J. Sol. Energy, vol. 81, 2007, pp. 1-7.
- [3]. Hasnat M.A., Siddiquey, A., Nuruddin.A, J. Dyes and pigments, vol. 66, 2005, pp. 185-188.
- [4]. Xiaohong Yin, Xin F, F Zhang, S Wang, G Zhang, J. environmental et engineering science, vol. 89, 2006, pp. 149-152.
- [5]. Belmouden, M., Assabbane, A., Ait-ichou, Y., J. Environ.Monit, vol. 2, 2000, pp. 257-260.

REMOVAL OF CHROMIUM FROM TANNERY WASTEWATER BY ADSORPTION ON PHOSPHATE WASTE

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Effluents from raw hide processing tanneries, which produce wet-blue, crust leather or finished leather, are very loaded with pollutants; especially organics, salts and chromium. It represents an immense pollution load. The uncontrolled release of tannery effluents to natural water bodies increases human health risks, environmental pollution and request very sophisticated and high cost technologies to be treated.

The aim of this study is to investigate treatment essays of tannery wastewater by adsorption using low cost bio-material: phosphate waste. The effluent used was sampled directly from tanning chrome fuller in a small industry located in the old medina of Marrakech. The phosphate wastes were taken from youssifia phosphate mine, and are used without any treatment. The average results of physicochemical characterization have shown that these tannery effluents are acidic (pH = 3-3.5), heavily loaded with chromium (2 to 7 g/L), organic matter (COD = 3 g O₂/L), chloride (values can reach 30 g/L) and then has a very high electric conductivity (50-60 mS/cm at 20°C). These values are much higher compared to Moroccan law which fixed value limits of Chromium discharge at 2 mg/L and 500 mg O₂/L for COD (SEEE, 2008).

Batch adsorption experiments were carried out by adding a given mass of adsorbent from 0.5 to 10g into series of 100mL vessels containing 50 ml of chrome tanning wastewater. The adsorbent dose, particle size of the adsorbent, the stirring speed and the temperature were studied; the evolution of the pH after adding the adsorbent was also evaluated.

Firstly, after adding the adsorbent, the pH of the solution increased from pH=3,65 to pH=5,2 without shaking, which is very important to optimize the adsorption test.

The optimization of the adsorbent dose used in the batch experiments shows that the maximum uptake of chromium ions was obtained with the dose 40 g/L. At this dose, the efficiency of chromium removal is around 85%, at the room temperature and 24 h of shaking.

The study of the effect of the adsorbent particle size shows that the rate of chromium retention is 84,29%, 85,50% and 84,81% at the particle size fractions [63µm; 125 µm]; [50µm, 63 µm] and [<2 mm] respectively. The study of stirring speed shows that 200 rpm offers the best adsorption result (84,59%) compared to 44,30 and 51,51% at 100 rpm and 150 rpm respectively. The effect of the temperature was also investigated. At t=50°C, the rate of the adsorption is around 99,21%, largely higher than those obtained at 30 ° C and 15 ° C (89,21% and 54,11% respectively). All the experiments were investigated for 24 h of shaking.

Therefore it can be concluded that the adsorption using phosphate waste could remove a substantial quantity of chromium. It is as an effective low cost bio-material to be used for chromium removal from tanning wastewater.

KEYWORDS: Tannery waste water; adsorption; phosphate waste; low cost treatment; bio-material.

DISAPPEARANCE OF AN AZO DYE IN AQUEOUS SOLUTION BY FENTON'S REAGENT

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Introduction

The objective aim of this study is to determine the influence of some operational parameters (initial pH of solution, initial concentration of hydrogen peroxide and initial ferrous concentration) on degradation of Basic Yellow 28 (Model pollutants of environment). The optimal experimental conditions for potential capability of disappearance dye were investigated.

Results and discussion

Effect of pH

The results (Fig. 1) indicated that the disappearance of Basic yellow 28 was significantly influenced by the pH of the solution and the optimal solution pH was observed at about 3.00.

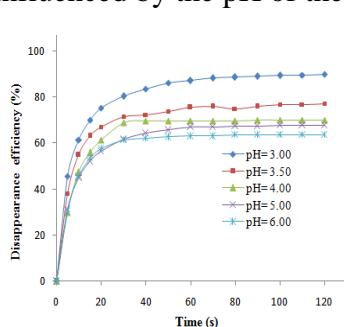


Fig. 1: Effect of pH

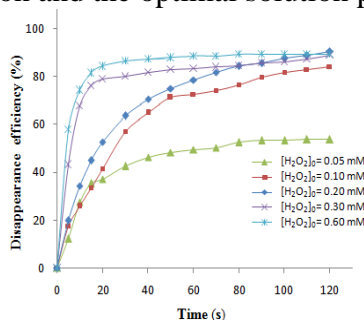


Fig. 2: Effect of [H₂O₂]

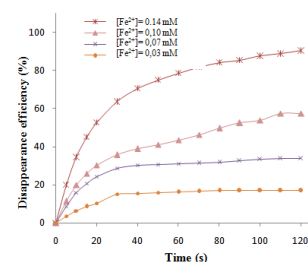


Fig. 3: Effect of [Fe²⁺]

Effect of the initial H₂O₂ concentration

According to the results are shown in Fig. 2, the optimal hydrogen peroxide concentration for the most effective disappearance of 13 μ M Basic yellow 28 is about 0.20 mM.

Effect of the initial Fe²⁺ concentration

The results (Fig. 3) indicated that the disappearance of Basic yellow 28 is remarkably dependent on the [Fe²⁺]₀ at fixed [H₂O₂]₀ and [dye]₀. At a low [Fe²⁺]₀ (0.03 mM), the degradation efficiency was 16.84% after the 2 min reaction time. Both disappearance efficiency and disappearance rate were increased with increase of [Fe²⁺]₀, the disappearance efficiency being 33.58%, 57.36% and 90.28% after the 2 min reaction time with [Fe²⁺]₀ of 0.07 mM, 0.1 mM and 0.14 mM, respectively. This is because more \cdot OH radicals are produced with the increase of [Fe²⁺]₀

Conclusion

The optimal operation parameters for the Fenton oxidation of Basic yellow 28 were 0.20 mM [H₂O₂]₀, 0.14 mM [Fe²⁺]₀ for 13 μ M [dye]₀ at an initial pH of 3.00 with room temperature.

Under these conditions, 90 % disappearance efficiency of dye in aqueous solution was achieved after 2 min of reaction.

KEYWORDS: Fenton's reagent, Basic yellow 28, Ferrous ion, Hydrogen peroxide, disappearance efficiency

PRETRAITEMENT DU LIXIVIAT DE LA DECHARGE DE FKIH BEN SALAH PAR TECHNIQUE DE COAGULATION

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En raison des exigences croissantes des normes de rejet, des nouvelles techniques ont fait leur apparition telles que les procédés membranaires, les procédés biologiques et les procédés physico-chimique.

Toutefois, l'efficacité de ces procédés à l'échelle industrielle est limitée, principalement à cause de la forte charge polluante du lixiviat, un prétraitement approprié est nécessaire. Plusieurs recherches portent sur les conditions optimales de coagulation, mais plus particulièrement sur l'influence du pH et la dose de coagulant. De ce fait, l'objectif de ce travail consiste d'une part, à étudier l'efficacité de la chaux sur un lixiviat jaune (pH acide) et brut, et d'autre part, à chercher et fixer la dose et les conditions optimales pour un prétraitement efficace et moins coûteux par coagulation en utilisant la chaux comme coagulant.

Alors que ce travail illustre les résultats obtenus par cette technique sur un échantillon d'un lixiviat prélevé de la décharge de Fkih Ben Salah(Maroc).

Après ajout de 9,90g de la chaux, les résultats obtenus ont montrés un abattement de 77% de la DCO, MES (51,68%), Al (32,33%), Fr (61%), Cd (19%), Mo (66,66%), alors que la quantité de boue extraite est de 26,83g et le volume de boues constitue est de 200ml.

Le pH est augmenté progressivement au fur et à mesure avec l'ajout de la chaux, de 4.21 à 7,99.

Mots clés : lixiviat, Coagulation, DCO, chaux

CHARACTERIZATION AND REMEDIATION OF TWO WASTEWATER TREATMENT PLANT EFFLUENTS

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The chemical contamination of water from a wide range of toxic derivatives, in particular heavy metals, aromatic molecules and dyes is a serious environmental problem owing to their potential human toxicity. Therefore, there is a need to develop technologies that can remove toxic pollutants from wastewaters.

Among all the treatments proposed, adsorption is a procedure of choice for treating industrial effluents, and a useful tool for protecting the environment [1]. In particular, adsorption on polymers and adsorbent materials are known to remove pollutants from water. The extending number of studies on adsorption of toxic compounds by modified adsorbents shows that there is a recent increasing interest in the synthesis of new low-cost adsorbents used in wastewater treatment. Much effort has recently been focused on various materials based on polysaccharides that can be obtained in large quantities and that are harmless to nature. Special attention has been given to cyclodextrins (CDs) which are natural molecules derived from starch [2].

The sampling campaigns were performed 2 times in output of the wastewater treatment plants (WWTPs). Water samples analyses were carried out on the total fraction by liquid-liquid extraction or by solid phase extraction. Either gas or liquid chromatography coupled with a mass spectrometry (GC-MS and LC-MS), static-headspace gas chromatography (HS-GC) analyses were realized for the identification of organic pollutants and total organic pollutant content was quantified by Total Organic Carbon (TOC) measurements. The main contaminants identified in wastewater were toluene and methylene chloride for volatile organic *compounds* (VOC), carbamazepine, caffeine, diethylphthalate, dibutylphthalate, phthalic acid, cholesterol and cresol for non-volatile compounds.

Different β -CD polymers were synthesized using various crosslinker [3]. Batch studies were performed with real and synthetic effluent. After adsorption onto CD polymers, we observed a decrease of the TOC content of the effluent. The polymers were found to be effective adsorbents. The proposed adsorption mechanism involves several kinds of interactions, formation of an inclusion complex due to the β -CD molecules through host-guest interactions, and the capacity of β -CD polymers for removing the organic pollutants at very low concentration levels. A further advantage of the β -CD polymers is that they can be recycled a number of times without losing their efficiency.

References:

- [1] Crini G., Prog. Polym. Sci. 30 (2005) 38-70
- [2] Morin-Crini, N., Crini, G., Prog. Polym. Sci., 38 (2013) 344-368.
- [3] Ma, M.; Li, D. Chemistry of Materials, 1999, 11, 872-874.

EXTRACTION AND ISOLATION OF CELLULOSE CACTUS CLADODES

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Cellulose is the material of tomorrow due to the reduction of fossil resources by overuse, think to replace them by other renewable resources, the only alternative is offered us in the long term is to focus on using most abundant materials on earth. Cellulose is a ubiquitous material in nature, it is a long macromolecule stereoregular chain and belongs to the family of D-Glucoses, repeating pattern of cellobiose, and this glucose polymer constitutes the main structure of many plants. The content varies depending on the plant species, 40 to 50% in wood and up to 95% in the cotton fibers (Mathieu Mazza et al, 2009) production annually about 100 billion tonnes against 4 billion tons of crude oil.

The objective of this study is the extraction of cellulose in several stages and the development of a waste based on cactus old rackets; type spineless *Opuntia ficus-indica*. The extracted cellulose showed a good isolation. The dispersion and purification of nanofibril by removing oils, mucilage, pectins, hemicellulose and coloring substances. The substitution of ethanol with acetone in the extraction protocol used as described by Youssef Habibi 2004, gave the purified suspensions of cell walls is well separated. However, the cellulose derived from sugar beet pulp, the pulp of mandarin the peel of prickly pear fruit requires a mechanical homogenizer. The cellulose obtained is a perspective material chemically and visually constitute from microfibrils cellulose, the suspensions are very stable in water. The infra-red analysis uses show the presence of the OH band of alcohol to 1317 cm⁻¹ (between 1310 and 1420 cm⁻¹), the output band CH connections at 2919 cm⁻¹ (2850 to 3000 cm⁻¹), a C = O band at 1620 cm⁻¹ (between 1650 and 1740 cm⁻¹), ketone or carboxyl acid, it explains that this fraction is impure and it still contains residual sugars probably acids esterified during extraction.

This type of cellulose has a beneficial interest in several areas because of their degree of polymerization of the microfibrils and their mechanical properties, such as oxidized cellulose bioresorptions and adsorbents of heavy metals in contaminated waters.

Keywords: Cellulose, nanofibril, racket cactus, extraction, *Opuntia ficus-indica*

Acknowledgment

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TEXTURE EFFECT OF NANO-LAYERED DOUBLE HYDROXIDES HIGHLY EFFICIENT FIBER-LIKE ADSORBENTS FOR WASTEWATER TREATMENT

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The problem of environmental pollution has become increasingly important in the world. The consumption and depletion of natural resources, especially water resources, have caused enormous environmental problems and have created severe shortage in many parts of the world. Recently, the possibility of an adsorption process by nanoparticles for the purification and the treatment of wastewater has become a viable option. In this way, the application of nano-Layered Double Hydroxides (nano-LDHs), especially their calcined products with high specific surface area, as adsorbents of toxic pollutant species has received considerable attention. However, there is another way to make better use of these materials which is avoiding calcination and finding new routes in order to develop the properties of uncalcined LDHs materials as adsorbents.

The LDHs materials are also known as anionic clays and they contain positively charged metal hydroxide layers resulted of the substitution of divalent cations M^{2+} by trivalent ones M^{3+} of somewhat similar radii. The generated positive charge is compensated in the interlayer region with intercalated anion-exchangeable, in aqueous or organic media, giving iso-structural materials type brucite. These anions can be of any types such as various inorganic and (bio) organic anions. Considering the fact that the diversity of the morphology of materials has a significant effect on functional diversification and potential applications, we have been focused on tuning the morphology.

We report in this study the synthesis of high surface area nano-LDHs in water. A simple and environmentally friendly method for the synthesis of a Fiber-like nano-LDHs. The effects of different synthesis conditions (aging temperature, aging time, rate of flow) and post-treatment parameters (washing solvent, dispersion solvent and calcination) on both morphology were investigated. The adsorption properties of LDHs with Fiber-like morphology have been investigated for azo dyes and compared to conventional stone-like or plate-like coprecipitated LDHs phases. It was observed that the amount of solvent used in the dispersion process can significantly affect the specific surface area of fiber-like LDHs. After calcination, the fiber-like morphology could be completely preserved. The LDHs samples were characterized by X-Ray Diffraction (XRD), Transmission Electron Microscope (TEM) techniques, Thermogravimetry (TG) and differential thermal analysis (DTA) and Specific surface areas and pore size were analysed using the Brunauer–Emmett–Teller (BET) method.

With relatively high specific surface areas, Fiber-like LDHs, when tested as adsorbents in azo dye removal, the as-prepared LDHs showed excellent performance, and were better than those of conventional coprecipitated LDHs. Various parameters were considered to optimize the azo dyes adsorption: Initial pH, contact time and initial concentration of the dye, molar ratio. The adsorption isotherms, kinetics and mechanisms for azo dye onto as-prepared fiber-like LDHs were also investigated. The adsorption mechanisms of azo dyes on LDHs were also proposed. The high uptake capability of the as-prepared LDHs make it a potentially attractive

adsorbent in water purification avoiding calcination step. Hence, a low cost material will be acquired with much more benefits namely preserving energy.

KEYWORDS: *nanoparticle; wastewater; azo dye; adsorption; layered double hydroxides.*

NEUTRALIZATION OF ACID MINE DRAINAGE AND METAL IMMOBILIZATION IN CONTAMINATED MINE SOIL AFTER POWDERED MARBLE WASTE APPLICATION

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Soil acidity greatly affects the availability of plant nutrients. The level of soil acidity can be adjusted by treating the soil with certain additives. The objective of this study was to evaluate the effects of the addition of powdered marble (rich on CaCO₃) which is an industrial residue produced in large quantities after cutting of marble, on neutralization of soil acidity and stabilization of metals present in mining areas.

The changes in the chemical composition of the soil were evaluated with PVC column (10 cm × 45 cm) test at the end of a 75-day incubation period. The columns were filled with 3kg of dried and sieved acidic soil (S) mixed with different rates of powdered marble waste (PM): [PMS1 (25%, 75%); PMS2 (50%, 50%); PMS3 (75%, 25%)] and a non-amended control treatment was also conducted. A fixed volume (2l) of distilled water was added weekly and the corresponding leachates were immediately collected for pH, CE and concentration of soluble metals analysis using Atomic Absorption Spectrophotometer "AAS". At the end of the day's incubation, soil characteristics were determined.

The results indicated that the powdered marble waste application significantly increased the soil pH (from 4.61 up to 8.5) and the CaCO₃ content (from 0.46 % up to 0.78%). However, it decrease the electrical conductivity values from 16 mScm⁻¹ to about < 2 mScm⁻¹ and the available metal forms Cu (from 12 mg L⁻¹ down to 3 mg L⁻¹), Zn (from 3.5 mg L⁻¹ down to 2 mg L⁻¹) and Pb (from 0.8 mg L⁻¹ down to 0.1 mg L⁻¹) and Fe (from 10 mg L⁻¹ down to 9 mg L⁻¹).

All the above-mentioned results show that powdered marble wastes play an important role in chemical stabilization of metals and reduction of sediments toxicity. Powdered marble residues could be suggested as an alternative to agricultural lime for the neutralization of acid soils. Carbonate resulting from the processing of marble is an effective amendment to neutralize soil acidity. The use of powdered marble due to their great potential as an acid-neutralizing material may also help reduce the negative effects of these materials as a waste disposal on environment.

KEYWORDS: Contaminated mine soil; Heavy metals, Powdered marble waste, Soil acidity, Neutralization

GAS TRANSFER AND ENERGY CONSUMPTION IN HIGH RATE ALGAL PONDS WITH TWO SYSTEMS OF AGITATION AIRLIFT AND PADDLE WHEEL

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The treatment technology of high rate algal pond performance differs from wastewater stabilization ponds by a shorter residence time, a shallow and constant mechanical agitation. This agitation can be done either by a jet of water, a paddle wheel, or an air diffuser (air lift). However, the most serious limitation of this technology is the gas/liquid mass transfer. Airlift system has been used to enhance gas-to-liquid mass transfer and create liquid circulation in the reactor. The overall oxygen transfer coefficient (K_La) is often the basis for comparison and evaluation of various reactor designs for use in gas-liquid mass transfer applications.

The determination of oxygen transfer coefficient in such a reactor seems difficult where biomass is active and consumes or produces oxygen. Hence the need to use a more appropriate method for this kind of situation. We used a tracer gas (Propane) that is not produced or consumed in the pond. This work reports on the methods used to evaluate the gas-liquid mass transfer of oxygen and comparison of energy consumption in the full scale Saada (Marrakech-Maroc) plant for two systems of agitation airlift and paddle wheel.

For the same water velocities the airlift system has higher global oxygen transfer coefficients. This means that at night the level of DO in the reactor can be maintained higher with the airlift as in some HRAP the photosynthesis cycle is active enough to yield an oxygen deficit at night or at least conditions where the dissolved oxygen concentration may become the limiting factor. Also for the energy consumption to get the same water velocities are lower, about 5 times with the airlift system than with the paddle wheel. In the same time the K_La coefficients are much higher (2 to 3 times) which results in a much more efficient oxygenation capacity, especially at the higher speeds.

KEYWORDS: Airlift, paddle wheel, hydrodynamic, high rate algal pond, oxygen transfer, energy

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REUSE OF TEXTILE WASTEWATER: BEHAVIOUR OF CONVENTIONAL POLLUTION PARAMETERS, AND PRIORITY AND EMERGING CONTAMINANTS WITHIN VARIOUS REFINING TREATMENT LINES

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Textile Prato district, together with the city of Prato (Tuscany, Italy), as well as the civil and textile areas of the Bisenzio valley (Tuscany, Italy) represent a whole a production zone of relevant volumes of domestic and industrial wastewater. In fact, these textile districts include many industries, that use large amounts of water for their processes. To this aim, groundwater has been widely employed, thus decreasing the availability of this primary water resource and, potentially, the accessibility for human consumption.

In these areas, the wastewater is treated by GIDA, a no-profit company that manages five wastewater treatment plants (WWTPs), characterized by different levels of technologies, depending on the quality and quantity of sewages to be treated. Furthermore, GIDA (together its industrial and public partners) has realized two centralized wastewater recycling plants (WWRPs) treating the effluent from the main WWTP of Prato area (i.e. the “Baciacavallo” facility), and feeding an industrial aqueduct with a length of about 64 km. The “Baciacavallo” WWTP has a complex treatment line, mainly consisting of a secondary biological oxidation and a tertiary advanced oxidation system with ozone. A number of positive environmental consequences derived from this management approach: (i) saving of groundwater for civil use; (ii) pollution reduction of primary water by industries; (iii) decrease of the environmental impact of wastewater effluents; (iv) satisfaction of the water demand of textile industries with good quality water resources.

In these WWRPs different advanced water treatment technologies have been adopted for improving quality of water to be reclaimed. Both systems comprise a preliminary treatment consisting in the addition of coagulants and flocculants, followed by a sand filtration; different solutions have been then tested for the final treatment of water, before its introduction in the industrial aqueduct. Among them, ozonation, activated carbon (GAC) and biological activated carbon (BAC) have been evaluated, the last two also coupled to disinfection with hypochlorite.

The different WWRPs treatment lines have been monitored with regard to a number of conventional pollution parameters, such as suspended solids (SS), chemical oxygen demand (COD), color, anionic and non-ionic surfactants: monitoring data show a high removal efficiency in both plants for the different technologies adopted. Moreover, starting from 1996, a great attention has been also paid to the evaluation of the fate of organic micropollutants (e.g. phthalates, PHTs; polycyclic aromatic hydrocarbons, PAHs; alkylphenol polyethoxylated, APnEOs and alkylphenols, APs) inside WWTPs managed by GIDA, and to the estimation of the point-source pollution for receiving water bodies, due to WWTP effluents. The mass balance of the various investigated organic pollutant classes (i.e. PAHs, APEOs and PHT) in the “Baciacavallo” WWTP, evidenced the high rate of actual degradation (57-85%, depending on the compound class considered), as well as the great removal efficiency (42-76%) of the ozonation stage. Hence, total PAHs and APEOs were found in the WWRP inlets at hundreds

of ng/L levels, whereas for PHT, concentrations of tens of $\mu\text{g/L}$ were determined. Color, which is one of the most critical parameters in textile wastewater, is also reduced, achieving transmittance (Tr) values up to 93%, due to the presence of the ozone-based oxidation. Effluent data from WWRPs show a further color reduction, with final Tr values as high as 99%. As regards other conventional parameters, high percent reduction of SS ($\approx 90\%$), total surfactants ($\approx 50\%$) and COD ($\approx 55\%$), have been observed, with effluent mean concentrations of $\approx 1 \text{ mg/L}$, $\approx 0.2 \text{ mg/L}$ and $\approx 13 \text{ mg/L}$, respectively. Very low effluent concentrations have been also determined for priority and emerging pollutants, such as AP₂EO, AP₁EO and their carboxylic and phenolic metabolites (concentrations well below $1 \mu\text{g/L}$) or estrogens (concentrations less than 1 ng/L).

Keywords: Reuse of textile wastewater; priority pollutants; emerging pollutants

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SPECIATION AND REMOVAL OF TOTAL CHROMIUM IN TANNERY WASTEWATER BY PHYTOREMEDIATION

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Waste discharge and wastewater treatment are sources of greenhouse gas emissions. The whole tannery industrial activity entails a series of tasks which pose threats to the ambient environment and health of working people. The tanning industry causes horrendous environmental pollution and high environmental impact of tannery effluents which makes its treatment an essential fact, mainly due to its volume, nature and concentration of pollutants such as tanning agents (chromium and tannin), color, organic matter and others.

Chromium is the most commonly used tanning agent. Basic chromium sulfate as used in leather tanning processes is not wholly taken up by the hides and skins. Its uptake is limited to 55–70%, and the remaining portion is discharged as waste. Therefore, about 40% of the Cr amount remains in the solid and liquid wastes. A number of methods have been used for the treatment of tannery wastewater. These include neutralization, cementation, sulphide precipitation, hydroxide precipitation, flocculation-classification, sand-filtration, precipitation, ion exchange, evaporative recovery process and sorption techniques. Phytoremediation is the use of green plants to remove pollutants from the environment or render them harmless. This technology has been receiving attention lately as an innovative, cost-effective alternative to the more established treatment methods used.

The aims of this work were on the one hand, to investigate the potential of a helophytic plant *Phragmites australis* (Cav.) Trin ex Steudel to remove chromium from concentrated tannery effluent in comparison to unplanted soil, under arid climate conditions. On the other hand, to determine the distribution, mobility, bioavailability and speciation of total Cr in the used soil. Six plots were filled to 15 cm in depth and 60 cm with respectively gravel and soil. Three plots were planted with young shoots of *Phragmites australis* (36 stems m⁻²), were taken from local and natural reed stand. Three unplanted plots served as control. The soil (88% sand) used for this study is coming from the Tensift river (Marrakech). Wastewater used originates from an industrial tannery in the Marrakech region. The experimental plots were feed exclusively by tannery wastewater 50% diluted, 3 times a week (10 litres per day). The water flowed vertically through substratum. The operationally determined speciation of total Cr was investigated by using selective five steps sequential extraction method.

The results indicated that during 13 months of experiment, the pH of the effluent at the outlet of two systems increases by two to three units. The planted pilot is more efficient in removing total COD 74% than the unplanted one 60.5%. The total chromium undergoes an overall removal of 99% for the two systems, which provides limpud purified water.

After 13 months of experiment, the results of the distribution of total chromium in the various strata of constructed red bed indicated a significant accumulation of Cr reaching 80% in the surface strata for two planted (PP) and unplanted (NPP) systems. Furthermore, the results showed that the Cr could migrate also towards deeper levels of the soil.

The speciation results indicated that the percentage of Cr in the exchangeable phase was very low. The Cr was mainly associated with the oxidizable phase 36±10 % for the PP system, 54±9 % for the NPP system and residual phase 26±3 %, 25±2 % for the PP and NPP systems respectively. The carbonate fraction presented 19.5±5 % for planted system and

10.7±5 % for unplanted system, while reducible fraction presented 18±6 % for the PP system and 10±4 % for the NPP system. Sequential extraction showed that *Phragmites australis* had the ability to partially transfer Cr from the oxidizable fraction mobile, to the less mobile fractions of carbonate and reducible. The results showed that *Phragmites australis* accumulated significantly high amount of Cr in the roots (1690 mg Kg⁻¹ dry matter). Furthermore, after 13 months of experiment, the soil accumulates high content of chromium (94%) and 5% of Cr accumulated in *Phragmites australis*.

The presence of plant ensures a sufficient porosity for the percolation of water for treatment, which makes it possible to treat a more important volume of wastewater and to reduce the required surface area by treated capita.

KEYWORDS: *Phragmites australis* (Cav.) Steudel; phytoremediation; tannery effluent; chromium; removal; speciation.

USE OF LOCAL MATERIALS FOR DECONTAMINATION OF DOMESTIC WASTEWATER BY MULTI SOIL LAYER SYSTEMS

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The objective of this study was to quantify the effectiveness of Multi-Soil-Layer (MSL) systems with different materials in removing of SS, BOD, COD, N-NH₄, N-NO₂, TP, *E. coli* and Streptococcus from domestic wastewater.

The materials used are mainly: pozzolan (Po), waste marble (Ma) and charcoal (Ch). The choice of these materials is primarily based on a technical-economic compromise that primarily includes the criteria of availability in the region and/or efficiency to remove pathogens and pollutants.

To carry out this work, four MSLs systems with different materials in soil mixed block (SMB) were applied. Untreated effluent was applied to each system at a flow rate of 400 L m⁻² d⁻¹ over 64 days period. The performance has been mainly evaluated by measuring differences in the quality of wastewater and treated water.

The experiment results showed that the improved MSL could effectively treat all organic matter, phosphorus and also fecal bacteria. By contrast, the N removal efficiency was low due to a strong nitrification effect without active denitrification.

Focusing on the removal of organic matter (BOD, SS, COD), NT and PT by MSL with different materials, we found that we could modify the structure of SMB depending on the water quality and treatment targeted to control and optimize the treatment efficiency of MSL systems.

This comparative study also showed that the system with pozzolan performed better than the other MSL systems in bacteria removal. Removal efficiencies of *E. coli* were 1,04 ± 0,01; 1,68 ± 0,23; 1,25 ± 0,06 and 2,26 ± 0,47 log₁₀ units for systems with (Br), (Ch), (Ma) and (Po) respectively and 1,06 ± 0,01; 1,53 ± 0,09; 1,14 ± 0,05 and 2,26 ± 0,39 log₁₀ units for Streptococcus.

KEYWORD: Multi-Soil-Layer (MSL); decontamination; domestic wastewater; pathogen; local material.

PHYSICOCHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF GREYWATER FROM A TRADITIONAL HAMMAM IN MARRAKECH

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In Morocco, 10 000 traditional public baths (Hammams) exist. They consume an average of 1.5 tons of wood and 60 to 125 m³ of water per day, which generates huge amounts of contaminated water needing treatment for possible reuse. The composition of greywater varies considerably, depending on the lifestyle of the inhabitants and their choices for the washing, bathing, etc. However, there is a very few scientific work that characterizes the quality of the greywater generated by traditional Hammams in Morocco. To fill this gap, the objective of this study is to determine the physicochemical and bacteriological characteristics of a traditional Hammam greywater in Marrakech.

The pH was measured using a multiparameter probe type WTW multi 340i/set (WTW Büro-weilheim, Germany). Biological oxygen demand in a 5-day test (BOD₅) was determined by the Warburg method, chemical oxygen demand (COD) was analyzed according to the dichromate open reflux method. The suspended solids (SS) concentration was estimated by the filtration method. Heavy metals were measured by Flame Atomic Adsorption Spectrophotometry type A.A- 6200 Shimadzu brand. The anionic surfactants were determined by the colorimetric method with methylene blue. Bacteriological analysis has focused on total coliforms, fecal coliforms and streptococques. Their analysis was done using the dilution method or the most probable number (MPN) technique for the samples suspected to be highly contaminated (Moroccan Standards, 2006). Concerning the culture medias used were essentially Tergitol for coliforms and Slanetz for streptococques.

The characterization of the greywater of the investigated traditional Hammam in summer period, reveals high levels of SS (129 mg / l), BOD₅ (464 mg / l) and anionic surfactant (4.99 mg / l). Analysis of heavy metals, show relatively high concentrations of iron (5,53 mg / l) in the two compartments of the traditional public bath (men and women), however the concentration of copper is slightly important in the women's compartment (0.55 mg / l). Microbiological analyzes show that levels of fecal contamination indicator bacteria (fecal coliforms) are high in the greywater of the two compartments of the Hammam (2.31 log UCF), their presence in these waters is an indicator of insufficient hygiene.

According to the results of this preliminary study, we conclude that the greywater of the public traditional bath (Hammam) are polluted and contain huge amount of heavy metals and anionic surfactant. A local treatment of the Hammam greywater is recommended for possible reuse.

KEYWORDS: Greywater; Hammam; physicochemical characteristics; microbiological characteristics; anionic surfactants.

REMOVAL OF SODIUM DODECYL SULPHATE FROM MOORISH BATH GREY WATER BY ADSORPTION USING ARGAN SHELLS

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In Morocco, about 10,000 traditional Moorish baths exist which are used by almost all of the population for personal hygiene. These Moorish baths consume an average of 60 to 125 m³ of water per day and generate huge amounts of greywaters.

Moorish greywater can be contaminated by some heavy metals, major ions and surfactants from traditional black soaps, shampoos, soaps, chemical and traditional hair dyes, clay (Ghassoul), toothpaste, hair, body fats, oils and disinfectants used for cleaning and maintenance of the Moorish bath (bleach, hydrochloric acid).

Among anionic surfactants used for personal care products, sodium dodecyl sulfate (SDS) is the most common product contained in commercial detergents, soaps, shampoos and shower gels. When present above a certain concentration in water, surfactants reduce the quality of water, impart unpleasant taste and odor, cause foams in rivers and effluent treatment plants, and cause both short and long term changes in the ecosystem. Its removal from Moorish bath greywaters becomes a priority before their reuse.

Among various wastewater treatment techniques, adsorption is supposed to be one of the best methods due to its inexpensiveness. The feasibility of using an agricultural product like Argan shells as an adsorbent in the removal of SDS from Moorish bath greywater was evaluated in a batch adsorption process. The Argan shell is considered among endemic species in Morocco (south regions) and is used in the production of oil, culinary and cosmetic products from their seeds. Argan oil processing produces large quantities of biomass residues (shells) which are investigated for heating purposes and in activated charcoal. The objective of this study was to investigate the applicability of Argan shell in the adsorption of SDS.

Greywater used in this experiment originates from traditional Moorish baths in Marrakech. The Argan shells were obtained from cooperative processing of Argan oil. They were washed thoroughly with distilled water to remove surface-adhered particles and water-soluble materials. Then they were sliced, spread on trays and oven-dried at 40°C for 48 h. The dried slices were ground and sieved to obtain a particle size inferior to 2 mm. The Sodium Dodecyl Sulphate was determined by the colorimetric method with acridine orange. The adsorption of SDS onto Argan shell was studied using a batch stirring method. Precise amounts varying between (0.1- 2.8 g) of Argan shell waste were introduced into glass recipients of 100 ml, and mixed with greywater with an initial concentration of SDS (9.10 mg/l). The initial pH of all solutions was in the range 7.6–8.1. The batch experiments were carried out at 25°C in a mechanical shaker at an agitation speed of 200 rpm. The concentration of the SDS in the solution after equilibrium adsorption was measured by a spectrophotometer at 467 nm.

The main characteristics of Moorish bath greywater indicated that the pH was 7.8. The concentrations of SS, COD, BOD₅ and Sulphate were respectively 216 mg/l, 819 mg/l, 452 mg/l and 141 mg/l.

The results showed that SDS concentration in Moorish bath greywater fluctuates between 8 and 10 mg/l exceeding the maximal limit recommended by WHO guidelines for surface water (3 mg/l).

The SDS adsorption equilibrium was attained after 10 hours of contact time. Almost 99% of SDS was removed having an initial concentration of SDS of 9 mg/l. The equilibrium adsorption data were interpreted in terms of the Langmuir and Freundlich isotherm models. The monolayer adsorption capacity of SDS was found to be 2.18 mg/g and the kinetic adsorption model is fitting with Langmuir model equation.

In conclusion, Argan shells could be considered as an effective, low cost material to remove SDS from greywater of traditional Moorish baths..

KEYWORDS: Moorish bath, Greywater; Anionic Surfactant; Sodium Dodecyl Sulphate; Adsorption; Argan shells wastes.

TREATMENT OF TABLE OLIVE PROCESSING WASTEWATER IN ACTIVATED SLUDGE PILOT PLANT

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Nowadays wastewater management become an obligation in order to prevent freshwater resources from pollution. In Morocco, the majority of food industries rejects wastewater directly in nature without any previous treatment, which leads to serious environmental impact.

In this work, treatment essays of table olive processing wastewater (TOPW) in activated pilot plant is investigated. The agro-food industry studied is located in Marrakech (Morocco) , and it processes different kinds of olives such as the green table olives , oxidized olives , shriveled black olive and turning olives. The production process consumes a big amounts of water and rejects the same quantity as wastewater (TOPW).

The characterization of TOPW shows a high content of COD (35 ± 1 g/l), high conductivity (30 ms/cm) and toxic phenolic compounds (4.5 ± 0.2 g/l) .Theses characteristics are varying according to the functioning steps of the industrial process and their relative wastewater percentage in the mixture of the global effluent. In spite of this variability, the mean characteristics ranged between biodegradable effluent intervals and could be apparently applied to biological treatment.

The evaluation of the treatability of TOPW is tested in 60 l lab-scale activated sludge pilot plant (AS) during a period of biomass acclimation of three months. The monitoring of the biomass characteristics (MVS, respiration rate, extra polymer Substances) and performances parameters such as Chemical oxygen demand (COD), Suspended solids (SS), volatile suspended solids (VSS) and phenol concentration were weekly analyzed .

Experimental results show that after total acclimation of the biomass to the industrial effluent, the MVS show an optimal growth of 5 g/l, and the OUR reached 20 gO₂.gmvs-1.h-1. The removal efficiencies attain 90% for SS, 90% for COD and until 85% for the phenolic compounds at the same period;

This percentage of removal shows that The Activated sludge process is an efficient system for the studied wastewater.

Keywords: activated sludge, Table olive processing wastewater, biomass, performances.

INTERET DE L'UTILISATION DES EAUX USEES SUR DES PLANTES INDUSTRIELLES A 'VALEUR ENERGETIQUE' CAS DE JATROPHA CURCAS

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En vue d'évaluer l'intérêt de l'utilisation des eaux usées sur la culture de *Jatropha curcas* et le rôle de celle-ci dans la conservation des eaux et des sols, et dans la production des énergies renouvelables, des essais ont été menés sous des conditions climatiques semi-aride du Maroc nord oriental (Oujda) dans le but est de suivre la croissance et le comportement de *Jatropha curcas* irriguée avec différents types d'eaux conventionnelles et non conventionnelles (dont la salinité peut être élevée jusqu'à 2,82 mmhos/cm).

Les performances de croissance de *Jatropha curcas* L. ont été étudiées sous différentes types d'eaux d'irrigation (Eaux usées, eaux fertilisées ou fertigation, eaux douces) et d'autres sans irrigation (sous régime pluviométrique). Les résultats obtenus ont montré :

- L'effet significatif des eaux usées sur le développement végétatif et le rendement (85%, $p < 0,3\%$).
- Accélération du cycle de développement et formation jusqu'à 3 pics d'inflorescences par an.
- L'application d'un stress hydrique a réduit significativement le taux de croissance et de rendement de *Jatropha* par rapport aux plants irrigués (un degré de 90%, $P < 0,2\%$). Son développement est lent, et la première floraison se trouve largement retardée (8 mois après) seulement après l'arrivée des premières pluies du mois de novembre.
- La fertigation a permis d'améliorer le rendement du *Jatropha* et d'accélérer le processus de reproduction (3 pics d'inflorescences). Ces résultats sont très similaires à ceux obtenus suite à l'irrigation avec les eaux usées épurées qui n'est qu'une autre manière de fertigation mais beaucoup moins chère.
- *Jatropha curcas* montre une bonne installation malgré la salinité élevée du sol (de 5,89 mmhos/cm à 7 mmhos/cm). Ce qui montre une parfaite adaptation de la plante aux différents types de sols : marginaux, squelettiques et fertiles.

La production de *Jatropha curcas* est étroitement liée à un apport hydrique, aux fertilisants, à la qualité du sol et au climat. Sur la base de ces résultats, l'association des eaux usées avec *Jatropha curcas* peut être un moyen : de lutte contre la désertification et l'érosion, de valorisation des terres marginales en utilisant *Jatropha curcas* comme plante de reboisement, ce qui contribuera au développement durable du pays par l'augmentation du patrimoine nationale en termes de biodiversité, et en termes d'énergie renouvelable 'une source d'énergie verte'.

Mots clés : Eaux usées, fertigation, *Jatropha curcas*, reboisement, développement durable.

THE USE OF OZONE PROCESS IN DRINKING WATER TREATMENT AND INVESTIGATION OF THE INFLUENCE OF OPERATIONAL PARAMETERS

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INTRODUCTION

During the 1970s it was discovered that the chlorination of drinking water produced carcinogens, such as the trihalomethanes [1]. Since then, environmental regulatory agencies, as well as drinking water treatment technologists worldwide, have been aggressively researching alternative disinfection methods which minimize the production of by-products of significant health risk. Ozonation has emerged as one of the most promising alternatives to chlorination and improvement of odors and taste of the drinking water [2].

However, ozonation does tend to oxidize bromide, which is present naturally in source waters, to bromate. The final concentration of bromate is dependent on the amount of bromide in the source water and applied ozone.

Bromate has been judged by both the US Environmental Protection Agency (EPA) and the World Health Organization as a potential carcinogen, even at the low µg/L level [3].

The aim of the present work is to confirm the effectiveness of ozone in water treatment and to optimize the experimental ozonation conditions, such as pH of raw water, concentration and applied ozone dose, air humidity and temperature and finally the investigation of the concentration of bromate ions in the treated water.

MAIN RESULTS

This work relates to a water purifying process which is an ozone treatment for removing organic substances contained in water, towards this end, the first step developed was to control the technical production of ozone and to investigate the parameters influencing the production of ozone, including its solubility and durability. Secondly, to evaluate the efficiency of ozone as oxidizing agent of water in order to improve the drinking water production quality.

The ozone treatment was carried out using a generator with a capacity of production of about 200 mg / h of ozone gas produced from the air and injected into the sample.

The concentration of aqueous ozone was determined by Spectrometric method indigo trisulfonate, the absorption of the indigo was monitoring by UV-Vis Spectrophotometer at 600 nm.

The yield of ozone production is influenced mainly by the air quality, this parameter is depending on the temperature and humidity of the air.

It was found that a difference of 8.5% in relative humidity & 3°C in air temperature caused a yield losses of up to 17.47 %.

The increase in pH has a double effect, it promotes the solubility of ozone, but it decreases its stability and therefore its lifetime.

The pH = 7.5 is the optimum pH for an effective treatment by ozonation.

Even at relatively low dose (2 mg L^{-1}), ozone has a powerful oxidizing effect, the reduction of organic compound was verified by monitoring the TOC parameter.

Also, as a result of the chlorination treatment which, some organochloride compounds were identified, being the most important those which are subjected to legislative control, namely trihalomethanes THM, after ozonation, the concentration of the compounds present is reduced to good percentages. The by-products formed after this treatment were, mainly, the bromate compounds. Their formation is a function of the injected ozone concentration and bromide concentration in the raw water.

Bromate ions were quantified at low $\mu\text{g L}^{-1}$ level, using ion chromatography method with many adaptations.

For a concentration of bromide less than 330 g L^{-1} and $6.5 < \text{pH} < 8.5$; applying an ozone treatment rate of about 2.5 mg L^{-1} , The dose of bromate does not exceed the WHO guideline value set at $10 \text{ micrograms L}^{-1}$.

The coupling ozone / activated carbon removes up to 70 % of the residual ozone and 90% of organic matter.

References

- [1] W.R. Haag and J. Hoigne, *Environ. Sci. Technol.*, 17 (1983) 261.
- [2] D.P. Hautman and M. Bolyard, *J. Chromatogr.*, 602 (1992) 65.
- [3] EPA (Environmental Protection Agency), Guidance Manual LT1ESWTR Disinfection Profiling and Benchmarking (2003).
- [4] P. Cooper, Colour in Dyehouse Effluent, Society of Dyers and Colourists, Bradford, 1995.

REMOVAL OF DISPERSE BLUE 165 FROM AQUEOUS SOLUTION BY MOROCCAN PHOSPHOGYPSUM

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The textile industry uses several wet processes that produce large amounts of highly colored wastewater containing azo dyes, which are the largest and the most common class of synthetic dyes used by the industry[1]. During the dyeing process, approximately 15–50% of the original concentration of the azo dyes that does not bind to the fabric is released into wastewater [2]. Scientists reported that the concentration of the dyes in textile wastewater may vary from 10 to 250 mg L⁻¹[3], while others have reported concentrations as high as 1500 mg L⁻¹ [4]. Besides azo dyes, textile wastewater also presents a heavy pollution load in terms of biological oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids. In this study, Moroccan phosphogypsum was used for the removal of disperse blue 165 from an aqueous solution. Physicochemical properties of the adsorbent were comprehensively characterized using XRD and FTIR spectroscopy. The influence of the initial dye concentration, pH, adsorbent dose and temperature was investigated in this study. The adsorption was evaluated using Freundlich and Langmuir isotherm models.

Keywords: Disperse blue 165, adsorption, kinetics.

EQUILIBRIUM AND KINETICS STUDIES FOR THE ADSORPTION OF ANIONIC DYES FROM AQUEOUS SOLUTION BY HYDROXYAPATITE-CHITOSAN-MONTMORILLONITE

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In this study, Hydroxyapatite-Chitosan-Montmorillonite (HAP-CHT-MMT) has been synthesized and their adsorption behavior was tested for the removal of anionic dyes found in textile wastewater. Indigo Carmine (IC) and Methyl Orange (MO) were chosen as models for anionic dyes. The prepared HAP-CHT-MMT was characterized. The effect of parameters like pH, contact time, adsorbent dose and temperature on the adsorption process was studied. IC and MO adsorption onto HAP-CHT-MMT film was better described by Langmuir isotherm and pseudo-second-order kinetic model.

Thermodynamic studies showed that IC and MO adsorption was exothermic and spontaneous in nature. Because HAP-CHT-MMT film could be recovered conveniently and possessed of excellent adsorptive property, it can be developed as an alternative adsorbent to decolorize or treat dye wastewater.

Keywords: Adsorption; Methyl Orange; Indigo Carmine; Montmorillonite ; Hydroxyapatite ; Chitosan; Isotherm models; kinetic models; Thermodynamic parameters.

KINETIC STUDY AND EQUILIBRIUM ISOTHERM ANALYSIS OF AZO DYES ADSORPTION BY FLY ASH

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This study was to evaluate the adsorption capability of fly ash from a thermal power plant (province of El Jadida) to remove Disperse Blue 79 (DB 79) and Disperse Blue 165 (DB 165) from aqueous solution. The experiments were carried out in a batch system to optimize operation variables: adsorbent dosage, initial dye concentration, pH and temperature. Adsorption kinetic and equilibrium isotherm of the fly ash were studied using pseudo-first order and second order kinetic equations, and Freundlich and Langmuir models. Further the thermodynamic parameters were also calculated.

Keywords: Adsorption, disperse blue 79 and 165, isotherms, kinetics.

INFLUENCE OF IMPREGNATION TIME IN PHOSPHORIC ACID ON THE ADSORPTION CAPACITY OF AN ACTIVATED CARBON PRODUCED FROM *O.FICUS INDICA*

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Environmental problems have increased since the first years of industrial development. Respect for the environment is more and more claimed. The level of consciousness is different from one country to another. Morocco has been one of the first countries that shows its engagement to preserve the environment since the first years of the 20th century by a set of legislation on the preservation of the environment (the first text related to water was published in 1914).

Among the pillars of the environment which has suffered the impacts of demographic and chronic industrial development we have the resources surface and groundwater. The fight against this pollution is much more difficult than what is deep in water or diluted in water is often invisible, and some toxic infiltrated the soil will often produce their effect after a long period and that many pollutants act complex synergies.

Much research has been done on this subject to find a manner to correct and compensate or mitigate the influence of human activity on water resources. Our work fits into this framework. Adsorption by activated carbon has been proven to be a successful physicochemical technique for the treatment of wastewater mainly for its simplicity, efficiency and ease of implementation. For the production of activated carbon there are three types of activation: physical, chemical and thermal activation. For the chemical activation we have basic activation that requires relatively high temperatures and acid activation. We opted for the acid activation with phosphoric acid.

We prepared an activated carbon from *O.ficusindica*. To study the influence of impregnation time with the phosphoric acid on the adsorption capacities of the *O.ficusindica*'s activated carbon we set the same conditions of preparation and activation and we display the impregnation time before calcination to study its influence on the adsorption capacity of our activated carbon. Too parameter was analyzed to evaluate our activated carbon: iodine number to evaluate the specific surface area and Methylene Blue adsorption to evaluate the adsorption capacity of our activated carbon on the textile dye waste water. The final Methylene blue solution was analyzed using an UV spectrometer at 660 wave length the methylene blue wave length absorption, the concentration of the final solution was then calculated from the calibration curve. The iodine number was tested according to the normalized method ASTM, D4607-94.

The results obtained in the present work show that it is possible to develop good active carbon by simple pyrolysis optimizing impregnation parameters. The experimental study in which to follow the influence of parameters of the preparation has yielded good active carbon by reducing the impregnation time. The values of the iodine numbers and the Methylene Blue adsorption of *O. Ficus indica*'s activated carbon reflected an interesting power of adsorption.

KEYWORDS: Adsorption¹; Activated carbon²; Acid activation³; Physical activation⁴; Chemical activation⁵; Thermal activation⁶;

DEGRADATION OF METHYL ORANGE IN WATER BY VISIBLE EXCITATION OF A $\text{Bi}_2\text{WO}_6\text{-Fe}_2\text{O}_3$ PHOTOCATALYST

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The development of new photocatalysts is attracting vast interest. Among them the Bismuth tungstate (Bi_2WO_6) is a typical n-type direct band gap semiconductor with a band gap of 2.75 eV and has prospective applications in electrode materials, solar energy conversion and catalysis. In addition it has been found that Bi_2WO_6 might act the same as a stable photocatalyst for the photochemical decomposition of organic contaminants under visible light irradiation.

The present study intended to dope Bi_2WO_6 with Fe_2O_3 to prepare $\text{Bi}_2\text{WO}_6\text{-Fe}_2\text{O}_3$ composite and investigate the degradation mechanisms of the composite in the presence of H_2O_2 . Methyl orange (MO) is used to imitate no biodegradable, toxic organic compounds. The photocatalytic activity of $\text{Bi}_2\text{WO}_6\text{-Fe}_2\text{O}_3$ to MO in the absence and presence of H_2O_2 is evaluated.

$\text{Bi}_2\text{WO}_6\text{-Fe}_2\text{O}_3$ composites were synthesized using a mechanical mixing; by adding the Bi_2WO_6 obtained by hydrothermal method to the corresponding amount of Fe_2O_3 and their photocatalytic activity to degrade methyl orange (MO) under visible light illumination supported with H_2O_2 were studied. The H_2O_2 react with photogenerated electrons leading to the production of hydroxyl radicals (OH^\bullet). The Fe_2O_3 acts like a Fenton reagent, accelerating the production of OH^\bullet .

$\text{Bi}_2\text{WO}_6\text{-Fe}_2\text{O}_3/\text{H}_2\text{O}_2$ system demonstrate much higher photocatalytic efficiency to degrade MO than pure Bi_2WO_6 . 50% of MO was degraded in 120 min visible irradiation and the peak disappeared after 90 min, and in $\text{Bi}_2\text{WO}_6\text{-Fe}_2\text{O}_3$ system the peak disappeared after 90 min (Fig1).

This study was performed at $\text{pH} \approx 6$ using Fe_2O_3 as a heterogeneous photo-Fenton catalyst in neutral and weak alkaline conditions of wastewater.

KEYWORDS: Heterogeneous photo-Fenton; OH^\bullet ; Bismuth tungstate; Methyl orange.

Acknowledgement

The authors thank the research group "Heterogeneous Photo-catalysis: Applications" in the Materials Science Institute of Seville.

PHOTODEGRADATION OF THE ANTIBIOTICS SULFAMETHOXAZOLE, HYDROCHLOROTHIAZIDE UNDER SIMULATED SUNLIGHT

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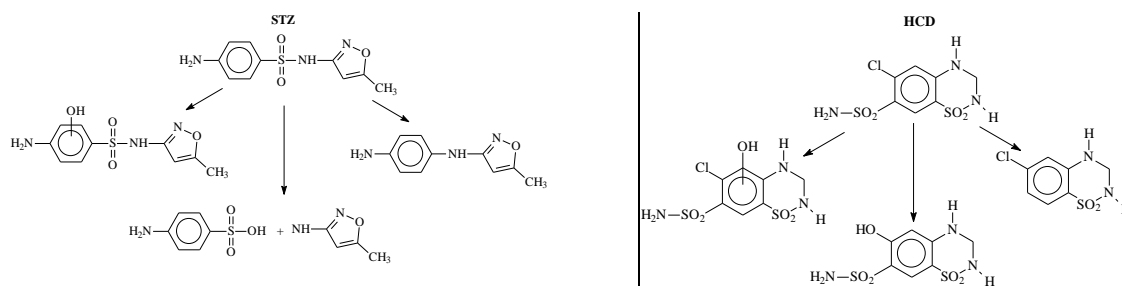
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Nowaday the emergence of pharmaceuticals in the aquatic and terrestrial environment have been a major concern. They have been detected in sewage-treatment plants, sediments, and soils as well as at surface and drinking water. So far, there is limited information in the literature on the fate of these compounds when they are exposed to solar light in the various environmental compartments. The objective of the present study is to investigate the degradation process of two different antibiotics Sulfamethoxazole (**STZ**), Hydrochlorothiazide (**HCD**) in aqueous solutions when exposed to simulated solar light. We mainly concentrate our effort on the kinetic studies by evaluating the degradation quantum yield as well as the effect of various parameters such as oxygen concentration, pH and the presence of inorganic ions. The main effect was observed by molecular oxygen parameter. We also make an important effort in the elucidation of the main intermediate and stable by-products. A lot of information is available on the stability and fate of parent compounds and not so many on their transformation products. These may present a toxicity level higher than the precursor substrate and should be identified and analysed. The structure elucidation was obtained by using the HPLC/ESI/MS and HPLC/ESI/MS² techniques in negative as well as positive modes and through the complete study of the various fragmentation pathways. The main involved photochemical processes were i) the scission of the bridge through a photohydrolysis process, ii) selective hydroxylation of the aromatic moiety iii) Desulfonation process and iiiii) in the case of HCD to dechlorination reaction. A mechanism was then proposed in the light of the kinetic and analytical studies.

Keywords: antibiotics, sunlight, photolysis, Sulfamethoxazole, Hydrochlorothiazide



Acknowledgement: The authors would like to thank the Faculté de Sciences de Bizerte, LACReSNE for the PhD grant.

LES EAUX DE LIXIVIAT DE LA DECHARGE DE FKIH BEN SALAH, MAROC, DEGRE DE POLLUTION ET SOLUTION ENVISAGEE

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Les déchets, générés par les activités domestique et industrielle, mis en décharge sauvage, constituent un risque de contamination de la nappe phréatique de la région de Fkih Ben Salah par infiltration du lixiviat. Ce dernier très riche en polluants organiques, minéraux et parfois bactériologiques impacte fortement les ressources hydriques souterraines.

Le présent travail s'est assigné comme objectif la caractérisation physico-chimique du lixiviat. Les résultats des analyses ont donné une valeur moyenne du pH de 4,7 qui reflète l'état de l'âge du lixiviat, il est en phases d'hydrolyse et d'acidogénèse. Ce lixiviat présente une forte charge organique (DCO = 18026 mgO₂/l ; DBO₅ = 6697 mgO₂/l). Le rapport DCO/DBO₅ est d'environ 3 dénotant, à priori, son caractère biodégradable.

De point de vue composition minérale, les résultats d'analyses du lixiviat ont montré que le percolât est riche en NTK total (2361mg/l), en phosphore total (144 mg/l), en orthophosphates (100,95 mg/l), en sulfates (1326,87 mg/l) et en ions chlorures (2051,11 mg/l). La composition en métaux lourds, quant à elle, elle est très importante. La concentration de fer est de 59,03 mg/l et celle du zinc de 8,59 mg/l.

Les caractéristiques de ce lixiviat montrent qu'il s'apprête à un traitement biologique, mais vue sa charge, notamment celle des métaux lourds, le recours à un traitement hybride intégrant la coagulation s'avère nécessaire. Le traitement par procédé anaérobie semble une voie propice pour l'élimination des polluants, mais aussi pour la production du bio-méthane.

Mots clés : lixiviat, acétogénèse, DCO, DBO₅, métaux lourds, caractérisation.

QUALITY EVALUATION OF TREATED WASTEWATER BY ACTIVATED SLUDGE USED IN AGRICULTURAL CASE STUDY (SANA'A CITY, YEMEN): PHYSICAL-CHEMICAL STUDY

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The Sana'a Basin is located in central highlands of Yemen. This basin is characterized by water crisis due to arid climate with low rainfall (170 mm/year), and drawdown of piezometric levels. Promoting water reuse of treated wastewater for irrigation could mitigate this water crisis. This study assesses the performance of Wastewater Treatment Plant (WWTP) by activated sludge of Sana'a City by analyzing the quality raw and treated wastewater predominantly by domestic sewage. A comparison with Yemen and international guideline reveals the results of pH, EC and PO₄ show that the effluent from WWTP are in admissible standard limit for irrigation. But, the others parameters such as BOD, COD, NH₄, TSS, phenols and heavy metals are very high than the standard values due to the overloaded of WWTP and industrial rejets. The added of facultative ponds can improve the performance of this station. Therefore, the quality of final effluent will be better.

Key-words: Wastewater, Treatment plant, activated sludge, Quality, Sana'a Basin, Yemen.

REMOVAL OF BACTERIAL INDICATORS AND PATHOGENS FROM DOMESTIC WASTEWATER BY THE CONSTRUCTED WETLANDS SYSTEM

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Sanitation techniques that are low cost and non-conventional are the adequate solution for the treatment of wastewater for small communities in rural areas.

The aims of this study were to evaluate the efficiency of a combined constructed wetland to remove fecal contamination bacteria indicators and pathogens from domestic wastewater. The wastewater treatment plant was composed of three vertical-subsurface flow constructed wetlands (VF) working in parallel followed by two horizontal-subsurface flow constructed wetland (HF) connected also in parallel. Wastewater samples were collected at the inlet of the storage tank (after the lift station) and at the outlet of both the VF and HF stages on a fortnightly basis over a year period for fecal contamination bacteria indicators and pathogens monitoring.

The reduction of indicators of fecal contamination has reached very high values ranging from 4.42 ULog for total coliforms, 4.68 ULog for fecal coliforms and 4.35 ULog for fecal streptococci. The plant has also significant performance in terms of removal of pathogens. The reduction is 4.41 ULog for *Escherichia coli*, *Enterococcus* 3.87 Ulog for *intestinal*, 4.2 Ulog for *Pseudomonas sp* and 4.41 Ulog for *Staphylococcus sp*.

Greatest microbial reductions were obtained by the HF compared to those in VF. Subsurface flow ecotechnologies offer great potential as robust and low-maintenance solutions for reducing the pathogen risk associated with domestic wastewater. The average values obtained in the effluent for fecal bacteria and pathogens were complying with the OMS guidelines and Moroccan Code of practice for wastewater reuse in irrigation and the treated wastewater can be used in agriculture without any health risk.

KEYWORDS: Bacterial indicators; pathogens; rural areas; Hybrid constructed wetland; domestic wastewater

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COMPARATIVE STUDY OF COPPER REMOVAL BY MONETITE AND NATURAL COMPOSITE MONETITE/CHITIN

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The contamination of water by toxic heavy metals through the discharge of municipal and industrial wastewater is a major global pollution concern. Their presence in streams and lakes has been responsible for several serious health problems and diseases for many fauna and flora species. Since copper is a widely used material, there are many actual or potential causes of copper pollution. Removal of the toxic heavy metal from waste water or decreasing its concentration to the permitted discharge level is important in order to preserve the water quality and environment. Adsorption or biosorption are one of the most popular methods for the removal of heavy metals from wastewater. A low-cost adsorbent is defined as one which is abundant in nature, or is a by-product or waste material from another industry. In this study, a newly identified biosorbent has been synthesized using wet precipitation method and used for selective removal of copper from wastewater. Natural composite monetite/chitin as a novel sorbent is expected to offer an attractive and inexpensive option for the removal of copper or other heavy metals by considering its simple synthesizing method. For this purpose, an adsorption study was conducted in batch system by optimizing the process variables such as initial concentration of copper (II), temperature, contact time, adsorbent dosage, solution volume and ionic strength. The kinetic modeling has shown that the experimental data followed the pseudo-second order kinetic model with an equilibrium time reached at 2 hours. During the first hour of the adsorption process, 60 and 80% of copper ions were removed by monetite and monetite/chitin respectively. On the other hand, when modeling the equilibrium state, the system was found following the Sips model with a maximum adsorption capacity at 30°C of about 6.7 and 26.9 mg/g for monetite and monetite/chitin composite respectively.

Keywords: Natural composite Monetite-chitin, monetite, adsorption, Copper, isotherms models

BUTYLTINS REMOVAL AND BEHAVIOR DURING WASTEWATER TREATMENT BY WASTE STABILIZATION PONDS

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Butyltins (BTs) include tributyltin (TBT) and its degradation products dibutyltin (DBT), and monobutyltins (MBT). The EU water framework directive (WFD) has classified the most toxic one (TBT) as a “priority hazardous substance”, whose emission, discharges and losses is targeted for phasing out or complete removal. The established TBT environmental quality standard for TBT in continental water bodies are less than 1 ng(Sn)/L, in the whole water sample (dissolved and particulate phases). Monitoring studies conducted on rivers, highlighted the fact that the discharge from waste water treatment plants (WWTP), is the main source of butyltins pollution in the water column and river sediments. Many studies have investigated organotins in conventional wastewater treatment plant (activated sludge, biofilters) but no studies were related to wastewater treatment by waste stabilization ponds (WSP's), who is widely used to treat wastewater from small rural town in Europe.

The aim of this work is, to provide data about the occurrence of butyltins in wastewater of rural town, to study the behavior of butyltins during treatment by WSP's and its relationship with the design characteristics of the ponds in each treatment step.

The presence of butyltins were investigated by GC-ICP-MS in samples of dissolved water (<0,45 µm), suspended particulate matter (SPM) (>0,45 µm), and bottom sludge, taken from each pond, and also from the influent and effluent of the WSP's of Gigean (GG) (6000 E.H), and Montbazin (MBZ) (4500 E.H). Both WWTP include two anaerobic ponds, and three facultative ponds, and pour in the watershed of « la Vène », a French Mediterranean river where the presence of butyltins has been demonstrated and linked to the discharge from those WSP.

In both WSP's results reveal the following points:

- The systematic occurrence of the three butyltins in all samples in the following order: MBT>DBT>TBT.
- In raw sewage butyltins concentrations in suspended particulate matter (SPM) ranged from 64% to 99%, and from 77% to 84% in MBZ and GG respectively.
- During treatment, settling of SPM in each pond is the main removal mechanism of butyltins especially in the two first anaerobic ponds where up to 93% (MBZ) and 60% (GG) of butyltins are removed by settling of SPM because of the 3m depth and high hydraulic retention time (HRT) that characterise those ponds.
- Settling of SPM, lead to the accumulation of persistent butyltin concentrations in sludge because of their slow anaerobic biodegradation.
- A high spatial variability of butyltins distribution was observed in the sludge, which is highly linked to hydrodynamics, which govern the SPM re-suspension, transport and settling inside each pond.

- Butyltins re-suspension was noticed in facultative pond during some sampling campaigns, which could be a result of the thermal re-stratification that characterise those shallow ponds.
- The shallowness, which characterise facultative pond, enable photo-degradation and aerobic biodegradation of butyltins in the supernatant.

Removal rate ranged between 60-97% and 52-87% in MBZ and GG respectively, but non-negligible butyltin concentrations is discharged from both WSP's.

KEYWORDS: Butyltins, waste stabilization ponds, Sorption, Bio-degradation, Photo-degradation.

TWO ACTIVATED CARBONS FROM AGRICULTURAL WASTE FROM *MAHIHOT ESCULENTA CRANTZ* IN METHYLENE BLUE'S DISPOSAL

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Food, water and climate are inextricably linked. Only a sustainable development model can face the difficult challenge in meeting the growing demands for food, water, and energy, which is further compounded by climate change (Rasula and Sharma, 2015). Among the crops, cassava has the lowest blue water footprint (Gerbens-Leenes et al., 2009) and its annual global production is estimated to be over 260,000 millions of tonnes (FAO, 2013). Cassava's root produces excellent flour quality (Shittu et al. 2008) but the process leads to agricultural wastes. Agricultural residues as precursors for activated carbon production are the focus of many studies because they are sustainable adsorbents with high porosity and high reactivity (Ioannidou and Zabaniotou, 2006). Using agricultural waste like peels as lignocellulosic biomass-rich materials for the production of low cost sorbents for water treatment application removes an ecological burden for the society (Bhatnagar et al., 2015).

One of the applications of those environment friendly carbons is the removal of hazardous dyes from aqueous waste. In this work, the adsorptive removal of Methylene Blue (MB) by two biochar obtained from cassava root (*Manihot Esculenta*) was studied in a batch system. The first one comes from cassava peeling and the last one from the pressing stage. After drying at sun light, grinding and sieving, the materials were chemically activated by phosphoric acid before carbonisation. The raw materials' starch contents was determined and ThermoGravimetric analysis were done. The carbons, Cassava Peel Carbon (CPC) and Tapioca Activated Carbon (TAC) were characterised using Fourier Transform Infra-Red spectroscopy (FTIR) techniques, the BOEHM method, the iodine number and the pH of zero point charge. The influence of pH was determined at room temperature ($25^{\circ}\text{C} \pm 2$) after 3H of 300 RPM agitation for carbons sieved to sizes between 40 and 90 μm ; 10mg of adsorbent for 50 ppm of dye solution and 25 mg for 200 ppm for CPC and TAC are respectively weighted. Two kinetic models (Lagergren's pseudo-first order and Ho's pseudo-second order) were used to calculate the adsorption rate constants. The experimental data isotherms at room temperature were analysed using the Langmuir and Freundlich equations. Biosorption of MB was investigated at different temperatures (298 K, 308 K, 318 K and 328 K) under optimised conditions. The changes of standard free energy, standard sorption entropy and standard sorption enthalpy were calculated.

The mechanisation of cassava flour production from *Manihot Esculenta* contributes to food security. The generated agricultural wastes has been identified to be effective adsorbents in wastewater's decolorisation. For MB elimination, the most starchy carbon's precursor (the product of the settling of the liquid effluent) give greater performance than the solide waste (cassava peels). When pH is around the natural pH of solution the yield is the best. Ho's pseudo-second order model was the more accurate and Langmuir's model provided the best fit for both carbons. The largest adsorption capacity obtained was 248.31 mg.g^{-1} for CPC and 596.78 mg.g^{-1} for TAC. The study of the thermodynamic revealed that the increasing of the temperature increase the amount of adsorbed dye. The adsorption was spontaneous and endothermic.

KEYWORDS: Adsorption; Methylene Blue; *Manihot Esculenta*.

Topic 3

Food security, sustainable agriculture and forestry

TOTAL FLUORESCENCE FINGERPRINTING OF CHEMICALS: CONTINUOUS MONITORING OF AGRICULTURAL SOILS AND WATERS

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INTRODUCTION

Millions of tons of pesticides are yearly released over the planet creating serious problems for human/animal health and for the environment, though it's difficult to estimate their exact number in worldwide use. Pesticides exceed several thousands of commercial products formulated from active principals (APs) and adjutants. Moreover, in a commercial mixture, only the AP is tested in the longest toxicological regulatory tests performed on mammals, while the adjutants are often kept confidential and are called inert by the manufacturing companies; these so-called inert products are recently found as one thousand times more toxic than the active principals [1].

In Morocco the average annual import of pesticides is about 12,000 tons and direct users of these products are poorly savvy workers, in addition to this the current stock of obsolete pesticides is reported as 800 tones [2]; among obsolete pesticides, there are organophosphorates (OPs) which may potentially act as warfare agents [3]. Moreover, no data relating to the estimated contamination levels of soils or waters are available; scientific investigations on the impact of pesticides focus principally on acute intoxication. Therefore, a continuous monitoring of the different environmental compartments (soil, water, and air) is increasingly needed for all the Moroccan territory to help sanitary authorities meet this challenge.

Currently the chromatographic methods are used through the international scientific community to determine the concentration of pesticides APs residues in soils or waters. In spite of their high accuracy, these sophisticated, expensive and thus low accessible techniques can be reserved only for laboratory accurate analyses and statutory inspection. Hence, emphasizing that assessing of pesticides occurrence in environmental compartments has to take into account the bulk of commercial pesticides mixtures (active principals and adjuvants), non-target analytical approaches must be considered. Additionally, owing to hundreds of samples to control, it is important to develop simple, rapid and inexpensive methods to assess continuously pesticides contamination levels in agricultural soils and neighboring waters. The purpose of this research is to palliate to this need by implementing a spectrometric approach, for continuous monitoring of soils and waters, which is direct, reliable, rapid and without use of organic solvents.

MAIN RESULTS

Fluorescence spectroscopy presents a high potential due to its high sensitivity, ease, rapidity of use and availability by virtue of its low cost when compared to chromatographic

techniques. Total excitation-emission fluorescence (TEEMs) and total synchronous fluorescence (TSFMs) mappings make it possible to identify remains of fluorescent pesticides in soils or waters. The present investigation, which is the continuation of our previous work [4], aims the creation/extension of a multi-component fluorescence-mapping database to fingerprint those fluorescent pesticides in large use in Morocco. The multi-component fluorimetric fingerprints must allow the direct identification of any fluorescent pesticide persisting in soil or water. After a large survey among farmers and agricultural product distributors, to target the most used commercial pesticides in the different Moroccan agricultural regions, 100 commercial pesticide mixtures have been fingerprinted by their TEE and TSF Matrices enriched by optimal Synchronous Fluorescence Spectra (SFS) and First Derivative Synchronous Spectra. The catalogue has been enriched by a PCA-based statistical study to constitute groups of pesticides with similar spectrometric fingerprints. The emitting similarity inside pesticides groups, despite different APs, was explained by similarity of adjuvants. As underlined above, these latter can be one thousand times more toxic than the APs. Four applicability tests were carried out on soil samples taken on different pre-treated fields crops in the great agricultural region of Doukkala. Remains of the organophosphate Orsalis 5% SC (fungicide), the carbamate Axlera 5G (insecticide), the pyrethrinoid Force 0,5 G (insecticide) and Proclaim 05 SG (insecticide) were identified by their spectrofluorimetric TEEMs, TSFMs and SFS/fd fingerprints. The present fluorimetric analysis approach seems promising; it is under extension to enlarge a maximum of homologated pesticides in Morocco. It requires thus continuous updating.

References

- [1] Mesnage R, Defarge N, Spiroux de Vendômois J, Séralini GE (2014) , *Biomed Res Int* 2014:179691
- [2] <http://lematin.ma/journal/2016/le-ministere-de-l-agriculture-et-la-fao-evaluent-le-projet/240938.html>. Accessed, 4th March 2016
- [3] Paola Carullo et al., *Sensors*, Vol 15, 2015, pp 3932-3951
- [4] Foudel et al., *Environmental Science and Pollution Research*, Vol 22, 2015, pp 6766-6777

IRRIGATION DEVELOPMENT

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INTRODUCTION

A program which has been integrated in the Algerian Government's policy involves the instructions given for the extension of the irrigated area of (01) million hectares. The main goal is to reach the 2.136.000 million ha in 2020, an increase of (01) million ha compared to the irrigated area in 2013 (base year) which was 1.136.000 ha.

MAIN RESULTS

The achievement of this goal is related to the water availability for irrigation. In fact, this goal can be achieved in wet rainy year while the opportunity of extending the irrigation area in dry year reaches only the 75-80% [1].

Additional implications and procedures could be considered to consolidate this program, particularly in dry year. Among them [1]: - Improving the irrigation efficiency by the gradual substitution of irrigation modes "wasters" in favor of modes "savers" such as sprinkler and drip.
 - Improving the current rotation systems.- the generalization of the use of purified wastewater.
 - Desalination can be also tackled.

LAUNCHED PROGRAM [1]

- Under the irrigation season of 2014, a development of 80.000 ha had been recorded where the irrigated area increased from 1 136 000 ha to 1 216 000 ha.

- In addition to this, a program is under way covering the equipment of a total surface of 143500 ha.- An area of 223 500 ha has been launched representing 22% of the goal.

- The realization of the generalization program of the use of modern techniques of water-savers irrigation systems with better organization of agricultural activity to a greater mastery of installations completed. This allows us to save more than 20% on the current water consumption equivalent for the irrigation of about 200.000 additional hectares.

A DEVELOPMENT OF SITUATION OF IRRIGATION EVOLVING 2000-2014 [1]

- **A spatial evolution**, from 350 000 ha in 2000 to 1 216 000 ha in 2014, representing 14.6% of the SAU, a multiplication of the irrigated soil by 3 with an annual average production of 61 700 ha. - **A qualitative evolution** by developing water-savers systems, irrigated area equipped with water-savers systems, sprinkler and drip, increased from 75 000 ha in 2000 to 604 000 ha in 2014 representing 49% of the area irrigated.

- **A water economic change** by the passage of a dose of $11.300 \text{ m}^3 / \text{ha}$ to $8.000 \text{ m}^3 / \text{ha}$ for 30% of water gained.

This effort will be consolidated and strengthened in the 2015-2019 program [3].

THE IMPACT OF THE PROGRAM ON THE FOOD SAFETY [2]:

- In terms of agricultural production under irrigation in irrigation perimeter, agricultural production will encounter high and sustainable growth rates. This will significantly reduce the import bill and improve the level of food safety which translates in particular by:

* The Securing cereal production (wheat) by irrigating 600.000 hectares, which represents 17% of the sown area under cereals annually (3.400.000 ha), with an expected irrigated average yield of 40 to 50 quintals / ha, we can guarantee a production of 30 million quintals of cereal.

* The development of forage cultures under irrigation of 200 000 ha, with an average yield in irrigated of 30 to 40 quintals / ha to guarantee a production of 08 million quintals.

* The development of legumes.

* The development of cultures maraichères and stratégiques arborables

* The development of intensive olive growing.

- Concerning the social level, the development of agriculture in irrigated areas will ensure jobs, direct and indirect, in the agricultural environment (one irrigated hectare generates on average 3 jobs), which at the end of this program 3 million jobs can be created. Also, it allows to improve salaries, and consequently helps stabilize the rural areas, to rebalance the agricultural economy and improve the living conditions of the population.

- As far as Economy, the implementation of this program will lead to the diversification of the agricultural economy through the creation of services units, in addition to the conditioning and processing units of the agricultural products.

Also, the agriculture's position will change in the agri-food chain and production systems, through the creation of agro-pôles régionaux in order to meet the needs of the processing industries and promote Integrated development

Acknowledgment

I wish to thank the director of the Agriculture hydraulic in Ministry water resources and environment for data and information requested on this theme.

References

- [1] Ministry water resources and environment, Water Resources Management, report. 2016, pp. 10-14
- [2] Ministry of Agriculture and Rural Development, irrigation techniques, report. 2016, pp. 15-20
- [3] World Bank, Water Resources Management, A policy paper. Washington, D.C. 1993, pp. 4-6

EFFECTS OF SIMPLIFIED CULTIVATION TECHNIQUES ON CONSERVING SOIL MOISTURE, AND CONSEQUENCES ON THE DEVELOPMENT OF DURUM WHEAT

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INTRODUCTION

Globally in recent decades, the plowing tillage mode tends to decrease benefit of different tillage methods, ranging from minimum tillage until direct seeding.

There exist indeed a great number of systems or farming techniques more or less well defined of tillage and establishment of the cultures. The traditional approach consists in gathering them according to whether they imply or not an in-depth work what gives two principal groups: work with ploughing and work without ploughing. It is generally accepted a third largest group, direct seeding, i.e. the seeder is the only machine of work of the ground used. Each one of these techniques has advantages but also disadvantages.

In order to understand the impact of new farming techniques on water conservation in the soil and the environment, an analysis of changes in water content, porosity and cone index soil under different techniques of tillage.

MAIN RESULTS

The tests proceeded on the level of the experimental station of the technical institute of field crops of Oued Smarin Algiers (Algeria). The texture of the soil is clay-muddy with clay 46,51%; 25,30% of silt and sand 26,79%. The culture used for our tests is the durum wheat (*Triticum durum*) variety (chen' S), the choice of the culture returns in the test routine of the introduction of the direct drilling to Algeria of the technical institute of field crops with a rotation wheat/bersim since 2004. This variety is an important culture of the Mediterranean environment, which is traditionally cultivated in rain conditions in the marginal zones of the semi-arid areas, with average outputs often very weak (in Algeria: 300 to 1200 kg.ha⁻¹). This variety has a roots system booklet with a great number of ramifications. This variety with a germinate capacity very high 97%.

The analysis of the results shows clearly that the technique used has an effect on the evolution of moisture, the porosity and the soil penetrometric resistance. The water content in the ground is preserved better with the direct drilling, its value reaches from 12,97% before sowing to 16,51% in the stage heading for the conventional tillage (TC); it passes from 13,83% to 16,73% for the minimum tillage (TM) and from 14,28% to 18,27 for the direct drilling. Porosity is slightly more important with the conventional tillage. As regards penetrometric resistance, the soil is more resistant in direct drilling where it reaches 158,4 N/cm².

The point of the penetrometer penetrates more in-depth on the piece worked with the conventional method (19,4 cm) then on minimum tillage to 15,05 cm then the depth reaches 14,02 cm for the direct drilling.

The results relating to the development of the roots show clearly that the roots system is very developed on the conventional tillage (TC) where the roots density is of 1,101 g/dm³, while in

the minimum tillage, a density is recorded of 0,805 g/dm³. At the plots direct drilling (SD) we have the lowest value root density is 0.638 g/ dm³.

We also notice that the diameters roots are more important on the plots with the conventional tillage averaged diameters is 1.38 mm, then the diameters of roots for the other two techniques are relatively close to each other, but always in the same order it is 1.14 mm for MT and 1.10 mm for the SD. The roots therefore grow best in soil plowed.

The estimated outputs are respectively of 36,19 q/ha for the direct drilling and of 50,03 q/ha for conventional tillage and it is only of 35,7 q/ha for minimum tillage.

In order to confirm the last observations, model made earlier, an statistical analysis by Linear regression was performed. This analysis to establish relations : $HSD = f(HTC)$, $nSD = f(nTC)$ and $RpSD = f(RpTC)$. These relationships are respectively:

$$HSD = -3,966 + 1,301 * HTC \text{ with } R^2 = 0,78$$

$$nSD = -1,318 + 1,006 * nTC \text{ with } R^2 = 0,75$$

$$RpSD = 3,711 + 0,745 * RpTC \text{ with } R^2 = 0,80$$

The statistical analysis showed that the values of p are lower than 0,05 and the coefficients of determination R^2 are higher than 0,75, which means that these relations are statistically significant on the degree of confidence of 95%. These relations confirm the effect of the farming technique on the conservation of water in the ground, on the value of total porosity and the penetrometric resistance of the ground.

The modeling of penetrometric resistance within water content (H) and porosity (N) gives us the following relations:

$$RpSD = -0,78 + 0,18 HSD + 0,17 nSD$$

$$RpTC = -4,40 + 0,56 HTC + 0,10 nTC$$

The Simplification of tillage operations, including the elimination of tillage, is a hot topic. It is likely to provide answers to technical requirements (water conservation in the soil) and environmental (fight against erosion, carbon storage, biodiversity) of today's agriculture.

RATIONAL USE OF WATER FOR AGRICULTURE IN EGYPT

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In Egypt, the acceleration of economic and demographic development, with rapid urbanization, growing industrialization and agriculture, has stepped up the pressures on the country's water resources, triggering an increase in their demand accompanied by the deterioration of water quality. This situation is alarming as Egypt is an arid country that depends on a single source of water which is the Nile River. Besides the population growth, social factors (poverty, quality of life, crop pattern, unequal distribution of water and consumer's behavior), physical variables (water resources and land expansion), economic and political elements are the main driving forces of water scarcity. Demand-oriented measures that can be

implemented in Egypt include: i) shifting to less water-demanding crops, ii) improving the efficiency of the existing public water supply system by reducing losses, detecting leakage and improving irrigation distribution and conveyance efficiency, iii) introducing tariffs for water conservation which might include various kinds of land or crop taxes, production charges, water pricing, or subsidies for water conservation, and iv) launching public awareness campaigns aimed at advocating a new water culture in a society based on the principle of conservation. A number of measures towards the rational use of water are already applied but still need extra

efforts to be fully successful. Using soilless cultivation techniques under protected cultivation can be the most efficient tool if it comes to water use efficiency and environmental sound production, allowing at least 30 and up to 50% water savings.

Enhancing the institutional organizations, involving the private sector, stringent laws and cooperation with the Nile Countries are considered a must to increase the water use efficiency, control water demand and reduce the over irrigation and the misuse of water. Optimum use of water resources is implemented through the reuse of drainage water, recycling the domestic and industrial wastewater and desalination. Cooperation with the riparian countries of the Nile Basin, through the Nile Basin Initiative, is expected to implement Upper Nile Projects and in return to lead to additional inflow into Lake Nasser.

KEYWORDS: Egypt: water resources, demand-oriented measures, rational use of water, water uses efficiency.

TOWARDS THE INTEGRATED MODEL: OVERVIEW OF RESEARCH ON OPTIMIZATION OF WATER IN IRRIGATION

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This In this work, we present an overview of research on optimization for both available water and consumer of water to population, industry and irrigation. Many technologies have recently appeared that can greatly contribute to improving the control and monitoring of the quality of water supply and consumer systems. They are based on programmable logical controllers (PLC), supervisory and data acquisition systems (SCADA), digital signal processors (DSP), wireless sensors, renewable energy sources and modern control theory.

The main limits to design highly-efficient systems, notably irrigation, are their incapability to integrate in the same model, a global management approach of the need water and the solar power potential available for Solar irrigation system through all a country. Our proposal approach integrates the too constraints on only model, this is useful both for the Green Morocco Plan's and the development of solar energy in morocco. Its applied will have a beneficial effect on the environmental impact for Morocco and for our planet and will be able to contribute to the socio-economic development, especially in countries were water resource is major constrain in agriculture or where water is not easily available for population. We will use the results obtained by our PROPRESMA project which gives the global solar power production to combine with a hydraulic potential through all morocco

KEYWORDS: Soil; irrigation; sensor; PV pump;

Acknowledgement

The main goal of "PROPRESMA" (www.propre.ma), consists on drawing grid-connected photovoltaic yield maps for the whole country with ground calibration using identical plants installed in partner institutions located in 20 different Moroccan cities

MODELLING ROOT-ZONE SOIL MOISTURE FROM OBSERVED AND SIMULATED SURFACE FLUXES

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Root zone soil moisture is a key information for quantifying the water need and consumption of plants, thus to optimize the rationale management of irrigation in semi-arid regions such as the Haouz plain. In situ measurements are not suitable for monitoring each crop field over large irrigated perimeters. The European H2020 REC project "Root Zone Estimates soil moisture at the daily and agricultural parcel scales for Crop irrigation management and water use impact - a multi-sensor remote sensing approach" proposes to develop innovative methodologies based on satellite observations.

As a preliminary study on the modeling of the root zone soil moisture, a model was developed to simulate the 0-30 or 0-50 cm soil moisture from the various components of the surface water budget: irrigation, precipitation, evapotranspiration, capillarity, vapor diffusion and percolation. These water fluxes were derived from either direct field measurement, or simulated by another type of model (e.g. the two-source energy balance model named TSEB). In particular, we compared two in situ measurement techniques for estimating surface water fluxes, which determine the moisture in the root zone. One was based on lysimetric measurements. This system had been installed in a 3 ha organic raspberry field near Chimbarongo (Chile) during the 2014-2015 agricultural season. The other was based on the measurement of turbulent fluxes by the Eddy covariance system. The latter had been installed on a 4 ha wheat field in a modern irrigation (R3) perimeter of the Haouz plain during the 2002-2003 agricultural season.

The results showed that the water fluxes in the ground in unsaturated conditions have a significant effect on the stock of water in the root zone, for both the flood irrigation (wheat field in R3) and canal irrigation (raspberry field in Chimbarongo) cases. On one side, the lysimeter method has the advantage of being able to quantify accurately these fluxes between the root zone and the deeper layers, but at a small scale about 1 m². On the other side, the Eddy covariance method has the advantage of measuring the evapotranspiration at a larger scale (about 1 ha) and being non-intrusive. With this data set, we achieved to simulate the root zone soil moisture with an acceptable accuracy at the station scale (RMSE = 0.025 m³ / m³ for wheat and RMSE = 0.019 m³ / m³ for raspberry). Temporally, the dynamics of the root zone water content is consistent with meteorological (rainfall) and anthropogenic (irrigation) forcing, and precisely follow in situ data during drying periods. The use of TSEB model allows us to simulate the vegetation transpiration rate and any potential water stress of crops. These promising results encourage us to further our research by coupling the modeling of the root zone soil moisture with remote sensing (Landsat-7/8, Sentinel-1 and Sentinel-2) data available at high-spatial resolution.

Keywords: root zone soil moisture; water and energy balance; evapotranspiration, remote sensing, lysimeter.

EVALUATION OF THE IMPACT OF THE USE OF TREATED WASTEWATER ON THE DEVELOPMENT AND METABOLISM OF CERTAIN SOLANACEAE CULTIVATED ON TWO DIFFERENT FLOORS

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Faced with the increased demand for water in either the agricultural or industrial, alternative supplies are possible to fight against any shortages. In terms of economy, the use of treated waste water will make available significant water quantities and at low cost in environmental terms, this water has an important nutritional source for plant saw its wealth of trace elements.

Our study considers the feasibility of wastewater treated after a die WWTP Lydec "Médiouna" in the irrigation of three species of Solanaceae very consumed by Moroccan households, either: Pepper "*Capsicum annuum*" Tomato "*Solanum lycopersicum*" and Eggplant "*Solanum melongena*". These species are grown in two different soils: one is the sewage treatment plant and the other in the Faculty of Sciences Ain Chock Casablanca.

In addition to growth monitoring and other morphological, metabolic study of three Solanaceae was achieved through some antioxidant enzymes considered stress biomarkers. The granulometric and physico-chemical analysis of the two soil revealed a difference in texture and levels of trace elements. In general, the soil belonging to the faculty responded perfectly to the soil requirements of the species studied. On the other hand, the evaluation of the physicochemical and microbiological water quality showed a remarkably rich in nutrients. However, some chemicals have introduced relatively high concentrations this happens sulfate (275 mg / l) which slightly exceeds the limits of water for irrigation (250 mg / l) or the mercury that reaches the threshold required standards with a concentration (0.001 mg / l). In response to the stress endured by these plants, enzymatic activity disturbances have been identified more pronounced way in crop plants in the plot of the treatment plant

The reuse of treated waste water is desirable in the context of a rational management of water resources and protecting the environment especially as it has several advantages guaranteeing good agricultural output provided to reduce levels of mercury and assess physicochemical and microbiological quality of fruits to ensure their safety and prevent bacterial contamination or accumulation of heavy metals that may endanger public health.

Keywords: Treated wastewater, Tomato, enzymatic activity, oxidative stress, Pepper, Eggplant, heavy metals.

STUDY OF THE FERTILIZING POTENTIAL OF THE TREATED WATER OF THE JIJEL WASTEWATER TREATMENT PLANT (ALGERIA)

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INTRODUCTION

Algeria is characterized by relatively limited water resources, vulnerable and unevenly distributed. For the Algerian population, renewable water resources are 550 cum/year per capita. The threshold of the scarcity of water is 1000 m³/person/year; therefore, Algeria is a country where water is scarce. In these conditions, the sector of agriculture is the largest water applicant. The reuse of treated wastewater can be an important alternative of the use clean and fresh water in the agricultural sector, especially in the country like Algeria, where irrigation uses up to 90% of the water consumed. The purpose of this work is to study the wastewater of the Jijel plant for agricultural use. Comparing our results with the WHO standards [1] and FAO [2] shows that it is possible to use this treated water in agriculture. This water contains significant quantities of nutrients. On the other hand, agriculture is a sector which has a high consumption of chemical fertilizers. The use of nutrient sources such as less expensive purified water can replace some of the chemical fertilizers and influence positively the profitability of farmers.

Main Results

The analysis results are interpreted and compared to recommendations and standards. During the period of study, the results obtained are presented in Table 1.

Jijel Plant	pH	T(°C)	(SAR)	Richard class [3]	EC (µS/cm)
		7.5	18.7	1.88	C3S1
	TSS (mg/l)	NO ₃ ⁻ (mg/l)	NH ₄ ⁺ (mg/l)	P ₂ O ₅ (mg/l)	K ₂ O(mg/l)
	4.61	13.8	0.8	10.7	13.6

Tab.1. Physico-chemical and agronomic features of treated water

Water pH is slightly basic with a mean value of 7.5 (Table 1), lower than the WHO [1] upper limit. This pH value is used to neutralize some acidic soils of the region.

The total suspended solids (TSS) represent the totality of the insoluble mineral and organic particles, floating or suspended, that are contained in wastewater. They are largely biodegradable. The average TSS content encountered was 4.61 mg/l. It is less than irrigation standards [1, 2] eliminating any risk of clogging of the soil and thus allowing their use in irrigation without the need of filtration. The nutrients contained in the treatment waters constitute an important quality parameter for the valorization of these waters in agriculture and landscape management. The most common elements in these waters are nitrogen, phosphorus,

and potassium. These elements are in significant quantities, but in quite variable proportions. Table(2) shows the amount of fertilizer given by a volume of 1,000 cum of wastewater. These values are compared to those offered by Faby and Brisaud [4]

Fertilizers (kg)	Nitrogen (NO ₃)	Nitrogen (NH ₄)	K ₂ O	P ₂ O ₅
Jijel Plant	13.8	0.8	13.6	10.7
Faby and Brisaud [4]	16-62 kg		2-69 kg	2-24 kg
Fertilizers (kg)	CaO		MgO	Na ₂ O
Jijel Plant	128.7		44.8	107.8
Faby and Brisaud [4]	18-208 kg		9-100 kg	27-182 kg

Tab.2. Fertilizer amounts (kg/ha) provided by a clean sheet of 100 mm of water corresponding to (1000 cum/ha)

A dose of irrigation of 5000 cum/ha/yr is adopted on the basis of an estimation of the water needs of crops grown in the area and taking into account climate needs [5].

Our study has provided analytical evidence on the nature of the waste water of the city of Jijel. Analyses of the purified water show the compliance of the majority of physicochemical parameters standards for reuse the irrigation water. This water provides important quantities of nutrients, resulting in higher productivity and substantial economic gains. This study shows how the reuse of waste water to an urban center allows the agricultural use of a large area. The wastewater reuse in irrigation of crops helps to increase water supplies for agriculture, thus improving their performance. This new approach allows the benefit of agriculture, in addition to water, fertilizer contained in the treated water, particularly nitrogen, phosphorus and potassium that improve crop yield without increasing production costs.

KEYWORDS: Wastewater, agriculture, valorization, fertilizer, irrigation

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INFLUENCES OF CLIMATE CHANGE ON MOROCCAN FIR FOREST BIODIVERSITY: COLEOPTERA AND HYMENOPTERA AS INDICATORS

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Climate change is a real and actual phenomenon, which threat nature stability and human life; their effects are already felt in some region of the planet. Southern and eastern parts of the Mediterranean basin are amongst those regions, increased extreme weather events and strong climate fluctuations that exceed the global average like heat waves, heavy rainfall of short duration and recurring storms were recorded recently.

Considered as the major component of an ecosystem since they play a critical role in soil protection, air quality, flood reduction, and a significant economic role in rural areas and for thenational economy as a whole; forest ecosystems have been central to the debate and climate change issues. In Morocco, this high significance is added totheir crucial role in the hydrologicalbalance and cross-cutting implications for socio-economic and human development. In fact, Morocco has a complex and important floristic and faunistic diversitymainly represented by forest ecosystems. It conceals valuable genetic resources both for the country itself and for theMediterranean countries community. However, biodiversity and genetic resources are in increased threat especially in theabsence of specific studies on climate change impacts in vulnerable areas such as forests.

The Moroccan and Spanish Pinsapo-Fir forests have been recognized as areas of high biodiversity and endemicy. *Abies pinsapo* is a relict species of the group of the circum-mediterranean firs. This endemic tree grows in small and isolated populations in southern Spain (West Betic Range) and northern Morocco (Rif Mountains). In south Spain, *A. pinsapo* (Boiss.) is currently found in about 3,600 ha, while it accounts for about 3,000 ha in northern Morocco. These forests were intensely damaged overcenturies and still damaged and affected nowadays by fires and climate change.

The Rif Mountains of northern Morocco represent a region of international significance from the standpoint of plant biodiversity with *A. marocana* (Trab.) among the endemic species.

The need to conserve and restore these relict and endemic fir forests has been increasingly recognized, being, for instance, a priority habitat under the EU Habitat Directive and being included in national and regional red lists and protection initiatives. Moreover, since 2006, the Pinsapo-fir forests are included in the Mediterranean Intercontinental Biosphere Reserve of Spain and Morocco, established by the UNESCO's Man and the Biosphere Program.

In addition to forests, insects are amongst the most affected and responding organisms to climate change because of its strong direct influence on their development, reproduction, and survival. Moreover, insects have short generation times and high reproductive rates, so they are more like to respond quicker to climate change than long-lived organisms, such as plants and vertebrates. Warming can potentially affect several aspects of insect life-cycle and

ecology, especially those directly controlled by energy availability variables such as degree. Consequently, potential responses include changes in phenological patterns, changes in habitat selection, and expansion and contraction of geographic and altitudinal ranges. Their ability to quick response makes them good indicators of current human-driven climate change.

In this context fits our study which aims the inventory of Coleoptera and Hymenoptera associated with the Moroccan relict fir forests of Talassemrane National Park, in a way to reveal their response and their use as bioindicators in biomonitoring of forests.

The sampling was led in 2 successive years (2013-2014), during 7 months (from April to October) using PolytrapTM and colored traps placed in 20 plots in the Talassemrane Fir and oak forest, combined with active field research; 74 family of Coleoptera and 43 family of Hymenoptera were recorded. Among those families are bio-indicators specially saproxylic beetles, parasitoid wasps, rare and endemic species. A First statistical test proves that there is a significant correlation between Temperature degrees and insects' arrival; also, an altitudinal effect on insects' distribution is demonstrated. In spite of the fact that the integration of insects in forest monitoring in Morocco still innovative, due to the lack of knowledge and the taxonomic obstacle related to this group of invertebrates; such studies are necessary to establish new management policy and improve actual forest management practices.

KEYWORDS: Fir forest; biodiversity; bio-indicators; insects; climate change.

PROTEOMIC ANALYSIS OF SALT STRESS-RESPONSIVE PROTEINS IN GERMINATING SOYBEAN SEEDS

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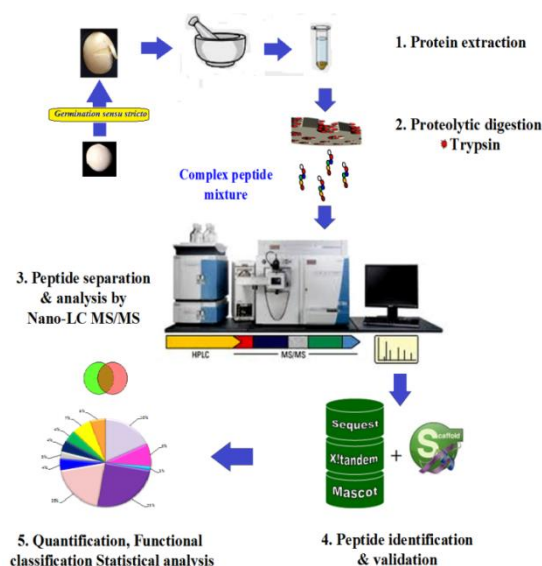
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Introduction

Soil salinity is one of the major and increasing problems of the agriculture worldwide, particularly in arid and semi-arid areas. While germination and seedling growth are often more susceptible to salinity damage, seed imbibition and radicle emergence are generally less affected by salinity in soybean than in other crop plants, thus making embryonic axis an appropriate model for investigating the potential mechanisms of salt tolerance in this species. Recently, several salt-inducible genes have been investigated in soybean. However, salt stress-inducible genes may lead to increase or decrease of salt-responsive proteins, thus it is difficult to make the precise phenotyping of stress tolerance, which is essential for breeding programs. Towards unraveling the mechanisms underlying this remarkable salt tolerance in soybean comprehensive quantitative proteomic analysis of proteins extracted from soybean embryonic axes following *germinantio sensu stricto* (GSS) under saline conditions was performed.



Main results:

As expected, even at growth-inhibition levels of salinity (100 and 200 mM), soybean embryonic axes maintain their ability to germinate displaying only an increase in germination time in a concentration-dependant manner. Nano-liquid chromatography-tandem mass spectrometry analysis of germinating embryonic axes, revealed that the application of 100 and 200 mM NaCl at GSS was accompanied by significant change in abundance (>2-fold) of 97 and 75 proteins, respectively. Most of these proteins (80%) were classified into three major functional categories, namely disease/defense response, folding/destination and storage, and primary metabolism proteins. Among all the identified proteins, thirty-one showed similar differential abundance under both salt treatments. Of these, 23 proteins showed increased abundance in response to salinity, mainly late embryogenesis abundant (Lea) proteins (8 proteins), a putative aquaporin TIP-type alpha, Cu/Zn-SOD, glutathione S-transferase and aldose reductase-like protein, a cytosolic aldehyde dehydrogenase C4. Interestingly, one of the signaling proteins whose abundance increases in response to salinity was found to be a 28 kDa heat- and acid-stable phosphoprotein-like protein, which is believed to be involved in regulation of cell growth and proliferation (Uniprot) and had never been reported before to be induced in response to any abiotic stress, suggesting that this protein may be involved in signal transduction during germination under salt stress conditions. The involvement of all these proteins in salt tolerance of soybean was discussed and some of them were suggested to be salt-responsive proteins.

Conclusion

Overall, our results suggest that the cross-protection of proteins against osmotic-, oxidative- and aldehydes-induced damages is essential to withstand the harmful effects of salt stress. These findings should be relevant to the identification of reliable markers useful for improving salt tolerance in soybean and related crops.

KEYWORDS: Glycine max (L.) Merrill; Embryonic axis; Salt tolerance; Gel-free proteomics; Label-free quantification.

DEVELOPMENT OF AN EVAPOTRANSPIRATION BASED ADAPTIVE IRRIGATION MODEL FOR ZEA MAYS (MAIZE) IN ARID SOIL USING NEAR REAL-TIME FIELD SPECTRAL REFLECTANCE SENSOR

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The strength of remote sensing in agricultural applications has been refining ever since the emergence of this domain. From satellite based to airborne imagery or terrestrial imaging systems, myriad of research and publications have come to assert an eminent contribution in all aspects and stages of agricultural practices. Recently, field spectral reflectance sensor technology has spread especially in precision agriculture and is incorporated to field machinery, spot sensors and even UAV. In arid zones such as United Arab Emirates characterized by sandy soils, scarce water resources and soil/water salinity, it is crucial to adopt the most optimized irrigation practices in order to be cost-effective in agriculture production and to keep a vital balance in the water food energy nexus. Hence, this study aims to propose an a near real time irrigation scheduling approach based on remote sensing evapotranspiration model using field Spectral Reflectance Sensor. Zea mays (Maize) was cultivated in open field trial, over twelve week period between October and December 2015 at the research station of the International Center for Biosaline Agriculture, Dubai, UAE. A Spectral Reflectance Sensor (SRS) was used to collect continuous data of Normalized Difference Vegetation Index (NDVI) over the whole duration, meanwhile conventional parameters such as canopy temperature, soil humidity, air temperature, plant height, biomass, chlorophyll and SPAD index were collected. To emphasize a significant variability of the NDVI based evapotranspiration model, three irrigation levels; 100, 50 and 25% of full irrigation and 4 salinity levels; 1, 2, 4 and 6 dS/m were applied. It was shown in this study, that spectral canopy reflectance could be a good indicator of water statute in the maize and an efficient tool for irrigation scheduling and management. In fact, starting from the second week after sowing, and immediately after the application of treatments, NDVI values for 100% fresh irrigation were clearly distinguishable with an average of 8% higher (based on absolute NDVI scale) than the plants with water or salinity stress. Furthermore, NDVI was correlated at 0.98 with the soil volumetric moisture. Similarly, significant relationships between NDVI and canopy temperature, plant height, total biomass and SPAD Index were obtained with respectively an R² of 0.74, 0.92, 0.98 and 0.87 which prove the appropriateness of this index as a good indicator of maize growth and productivity. Hence, the combination of all semi empirical models of NDVI vs soil humidity, crop growth and biomass etc. has allowed the development of a preliminary maize evapotranspiration equation based mainly on NDVI index for in UAE typical arid soil. This model allows calculating the reference and maximal crop evapotranspiration as well as water requirements for a given day, permitting a fully or semi-automatic irrigation scheduling. The obtained results, in this preliminary research, are very encouraging towards the adoption of this technique for a better irrigation management and improvement of water use efficiency and water security. However further specific field trials and accuracy assessment, as well as up-scaling strategies for a better generalization for full

scale application in UAE farms should be carried out. The complementarity of near real time Spectral Reflectance Sensor with existing UAE national EO satellites program (e.g. Dubaisat-1, DubaiSat-2 and coming Khalifa Sat) is worth to be studied for a better synergy to improve crop growth models with spatially explicit data.

KEYWORDS: *remote sensing, NDVI, Maize, biomass, Canopy temperature*

Acknowledgement

This research was funded by USAID through FABRI project (Further Advancing the Blue Revolution Initiative, Water Innovation Fellowships (WIF) Small Grants). Our regards go to DAI technical and management staff for their coordination and support. We are grateful also to ICBA center for providing all field and lab facilities to achieve this work.

INTRA-VARIETAL GENETIC DIVERSITY OF FOUR FIG VARIETIES (*FICUS CARICA* L.) GROWN IN NORTHERN MOROCCO USING MOLECULAR MARKERS

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The common fig (*Ficus carica* L. Moraceae) is one of the oldest fruits grown in the Mediterranean. In Morocco, fig cultivars are very diverse and offer a wide range of cultivars particularly in the north. The fig cropping is always accompanied by a non-precise recognition of varieties. Despite the continuous progress made in characterization and conservation of fig genetic resources, fig acreage extension is confronted with problems such as lack of vegetative material availability from authentic selected varieties having better agronomic characteristics. Previous studies have shown that the varieties widely cultivated in Morocco are polyclonal types with the presence of varietal confusion problems due to the problems of synonyms and homonyms. This research aims to use ISSR molecular markers to study intra varietal genetic diversity among four local fig varieties (Naboute, El Quoti, Ghoudane and Massari) widely grown in northern Morocco and check if these varieties are polyclonal types and/or present a confusion due denomination problems.

Exploitation of 8 ISSR primers allows a genetic characterization of all genotypes belonging to the four varieties. The varieties chosen are Nabout for Taounate region, El-Qouti and Massari for Ouazzane region. Thus, for the same varieties were used for comparison the reference varieties of the Ain Taoujdate Experimental Field and those of the ENAM collection. A comparison was also made between Ghoudane clones of both collections. In all, the young leaves of 35 genotypes (10 Naboute, 14 El Quoti, 8 Massari and 4 Ghoudane) were collected in April.

The hierarchical classification (fig. 1) perfectly illustrates the genetic relationships between 35 clones of varieties. Right away, we found that between 74% and 83% of genetic distances, the genotypes are classified into subgroups to distinguish 3 clusters. Each brings together clones of each of the three varieties Naboute El Qouti and Massari. Data analysis shows the similarity between profiles of few clones of the same variety. The pairwise comparison shows that some clones are genetically close with less than 6 different markers while others are distinct by 7 to 17 polymorphic bands. The small differences in ISSR molecular markers may be due to somaclonal variation phenomena that are widespread among the fig cultivars whereas the great differences indicate that the clones are genetically different and denominations are probably due to varietal confusion and homonyms problems.

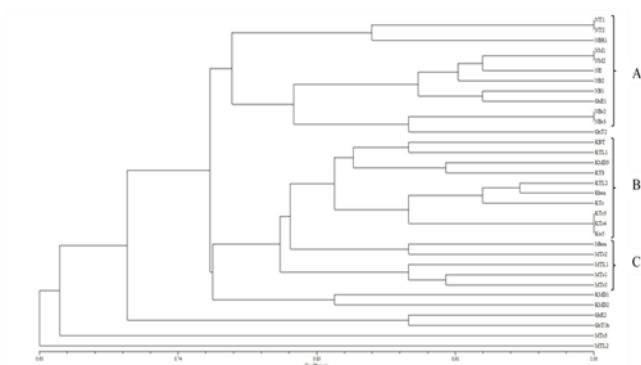


Fig.1: Phylogenetic tree of fig studied genotypes based on the UPGMA method and the calculation of distance

For these 4 varieties widely grown in northern Morocco (Naboute, El Qouti, Ghoudane and Massari), the present investigation has shown the existence of intra-varietal genetic diversity and perhaps problems of varieties recognition by growers. Furthermore, a detailed work that combines molecular (especially the SSR markers) and pomological characterization is required to clarify this variability.

KEYWORDS: *Ficus carica*; intra-varietal diversity; ISSR markers; polyclonal

BIO-FERTILIZER BASED ON MICROALGAE: AN ALTERNATIVE TO CHEMICAL FERTILIZERS IN AGRICULTURE

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Introduction

Waste effluents from agro-industrial activities can be an environmental management problem due to their high nutrient loads and associated CO₂ emissions. The European Project LIFE+ Integral Carbon proposes the use of soil microalgae grown in photo-bioreactors for CO₂ sequestration using residual effluents of agro-industrial activities. The objective of this work was to test the application of algae cultures as bio-fertilizers and their potential to replace or supplement the use of chemical fertilizers in agricultural production, reducing the C-footprint of agro-industrial processes.

Methods

Algal species were isolated from the Ap horizon of an irrigated field located at in Cáceres (Spain): N 40°1'52.85'' W 5°36'49''. Soil samples were dispersed in 100 mL of BG11 medium and thereafter in petri dishes with BG11-agar until pure colonies were obtained. After morphological identification, pigment composition was determined by LC-MS from a methanol extract and identified to species level by DNA sequencing. Pure algal strains were cultured in 15 L photo-bioreactors with a 16:8 photoperiod, photon density of 100 μmol m⁻² s⁻¹ and 28°-18°C during light-dark periods, respectively. Four solutions were used in this experience: a culture of *Chlorella sorokiniana* concentrated by centrifugation at 2,000 g to obtain 2 g DM L⁻¹ of final algae concentration (*Solution 1*); spent algae growth medium filtered at 0.2 μm (*Solution 2*); harvested algae re-suspended in new BG11 (*Solution 3*) and sterile BG11 medium as a control (*Control*).

Germination tests were conducted with seeds of wheat in Petri dishes between two layers of filter paper soaked with 5 mL of the different treatments. After 6 days of incubation, the number of germinated seeds and the root length were determined. All the treatments were made in quintuplicate using sterile water as a control.

For the pot experiment, a mixture of vermiculite and peat (1:1 v/v) were introduced in the wells of a germination tray with a pre-germinated seed of wheat. After the addition of 5 mL of MiliQ water, 5 mL of the solutions of the different treatments were applied and the trays incubated in a climatic chamber for two weeks, under the described conditions of photoperiod and light and with periodic irrigation. At the end of the experience, root and stem lengths and total fresh biomass of aboveground and belowground parts were determined in 24 plants per treatment.

Results and discussion

The germination test showed a strong saline effect of the media which strongly inhibited the germination in comparison with water. The presence of algae in both media did not have a

significant effect on germination. In the pot experience, fresh weight of roots, stems and total plant biomass of plantlets were always bigger in treated pots than in controls; however, only the treatment with *Solution 2* displayed differences which were statistically significant from other treatments; the average stem length was also higher in this media.

These results show that algae and their extracellular exudates likely play a role in plant nutrition. This is an important consideration in future agronomic application of algae cultures. The characterization of extracellular compounds and enzymatic activities in the extracellular medium of algae are under investigation in terms of nutrient solubilization, production of auxin-like compounds or siderophores. In planned future experiments, soil nitrogen-fixing microorganisms, more precisely some cyanobacteria, will be also tested because these phyto-stimulant effects will depend largely on the algae strain used, since some are in greater intimate contact with the plant roots.

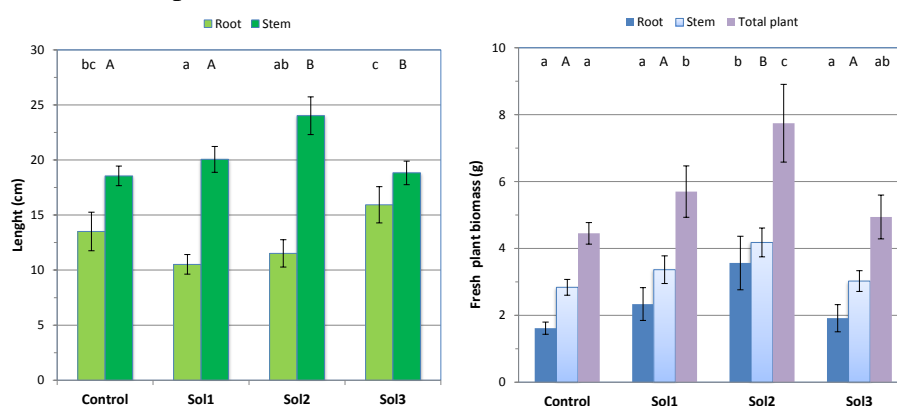


Figure 1: Length of roots and stems and fresh biomass of roots, stems and in the whole plantlets after treatments.

Error bars display 95% of confidence interval. Different letters displayed significant differences between means of each series.

KEYWORDS: Bio-fertilizer; soil algae, Chlorella, CO₂ fixation.

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ETUDE ET MODELISATION DE PHENOMENE D'ABSORPTION DANS LE SYSTEME BOIS/EAU

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Wood is a building material and furniture that holds a prime place among the materials through its mechanical properties, thermal, its aesthetic appearance and fluid transfer properties.

Wood absorbs water when immersed in liquid water, and of course, the concentration of water in the timber is greater than that associated with the PHF. This absorption of water is an important phenomenon, as it may allow the release of the chemical previously located in the timber.

The transfer of the water inside timber is governed by Fickian diffusion, the driving force transfer being the concentration gradient and the second law of Fick can express the change in concentration with time mathematically. In this study, we investigated the phenomenon of water absorption into the wood.

KEYWORDS: *Transfer, Diffusion, Modelisation, Finite difference method*

VALUATION OF SUNFLOWER GERmplasm SELECTED FOR COLD TOLERANCE IN MOROCCO

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Agronomic potential of traditional sunflower spring varieties is reduced because flowering and grain filling are often exposed to drought occurring in the middle or at the end of the crop cycle. To overcome this, new breeding strategy consisted of selecting varieties tolerant to winter cold in order to shift to autumn or early winter planting. Nowadays, 'Ichraq' is the only one registered autumn variety. The objective of this research is to evaluate various genotypes having been selected in different environments under autumn planting conditions. This germplasm was planted early at winter during two years (2013 and 2014) at 'Annoceur', a mountain site known for its pronounced winter cold. Morphological, physiological, agronomic and technological parameters were considered for the germplasm assessment. Analysis of variance showed significant differences between genotypes for most of these parameters. Plantlet initial vigor average was 3.5 varying from 1 for genotype M32 to 5 for AN8. Leaf area average was 162 cm² varying from 25 to 375 cm² for genotypes M17 and AN34, respectively. Total chlorophyll content average was 43 mg/g, varying from 28 to 79 mg/g for genotypes K7 and M29, respectively. Number of days from sowing to flowering varied from 162 d for genotype AN21 to 180 d for genotypes M27 and M29. Mean seed yield per plant was 49 g, with a large variation from 8 to 110 g for M18 and K8, respectively. Mean seed oil content was 36%, ranging from 22% for M8 to 47% for K4. Correlations between parameters were also studied and discussed. Genotypes having exhibited more performance than 'Ichraq' were selected to develop new sunflower germplasm suitable for autumn or early winter sowing.

Keywords: Sunflower, germplasm, cold tolerance, autumn planting, Morocco.

MICRO-ALGAE DEVELOPMENT ON SOLID SUPPORTS

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Introduction

The most abundant photosynthetic microorganisms in nature are cyanobacteria and certain eukaryotic microalgae, including green algae, red algae, and diatoms. In general, microalgae are characterized for their fast growth, non-competition with food cultivations and high efficiency in fixing CO₂; moreover, their high content of lipids and carbohydrates make them an excellent raw material for biofuel or for animal feed production. Moreover, cyanobacteria are one of the very few groups of microorganisms that can convert inert atmosphere nitrogen to an organic form and they can function as primary colonizers in a diverse range of aquatic and terrestrial habitats. In the 1970s, the inoculation of soil with selected cyanobacterial strains led to the promotion of these biofertilizers in paddy rice cultivation in South East Asia. Analyses of the abundance and diversity of cyanobacteria isolated from paddy soils from North and Eastern India have revealed the dominance of heterocystous forms, with *Nostoc* and *Anabaena* comprising 40–90% of the isolates.

Alternatively to soil inoculation, some applications have included external cultivation of cyanobacteria in small ponds or holding tanks, for later harvest and application as a bio-fertilizer. However, there are a number of disadvantages for aqueous cultivation, such as the low productivity rates due to limited light infiltration, the contamination with invertebrate predators or the low diffusion of gases. Porous Substrate Photo-bioreactors (PSBRs) would be a good alternative to liquid cultivation reaching high biomass yields with advantageous light exploitation. PSBR systems are not wide-spread, and require a balance of cost, harvest feasibility, and parametrization. Our study was directed towards the evaluation of different solid supports: woven fiber, geotextile and bio-char, as a media for growth of filamentous algae or cyanobacteria.

Methods

Two strains of filamentous algae isolated from an agricultural field: *Anabaena* sp. and *Klebsormidium* sp. were grown in sterile medium BG11 in stirred flasks into a climatic chamber with a 16:8 photoperiod, photon density of 100 μmol m⁻² s⁻¹, 28°-18° C during light-dark periods. Algae concentration in the liquid media was periodically assessed measuring the turbidity by absorbance at 750 nm and when the maximum growth was reached, dry algae biomass was determined gravimetrically after filtration through a glass fiber filter with 1 μm mesh.

For this experiment, three solid supports were tested: woven fibers, geotextile and pink bark biochar produced at 900 °C sieved to 2 mm. All the solid supports were washed two times with MilliQ water and dried at 70 °C for 24 h. Textiles were cut to fill the bottom of a Petri dish and biochar was applied in enough amounts to completely cover the bottom of the dish and to reach similar height to the other treatments. Triplicate Petri dishes (without lid) were

weighed to ± 0.1 mg precision (Weight A) per treatment and algae strain, including controls without solid supports. Twenty milliliters of homogenous algae suspensions were inoculated in each plate and incubated in the climatic chamber under the described conditions. After 20 days of incubation, all the Petri dishes were dried at 70°C and weighed (Weight B). The weight of dissolved salts present in BG11 culture medium was evaluated separately by evaporating 100 mL to dryness in triplicate (Weight C).

Dry algae biomass was calculated as difference: B-C-A. One-way ANOVA was applied, after checking for assumptions of normality and homogeneity of variances, to determine significant differences between treatments. Tuckey's test was used to differentiate between means.

Results and discussion

For the two species of algae, *Anabaena* sp and *Klebsormidium* sp. the growth of algae and cyanobacteria was higher when a solid support is introduced in the liquid culture. Dry biomass culture for both species was always high in the sequence: geotextile > biochar > woven fiber > control. Geotextile is the most advantageous support due to its more porous structure that allow the growth of the filamentous algae in the inner surface of the polymer; using this support, algal biomass yields were increased by 14% and 12% for *Klebsormidium* and *Anabaena*, respectively. The growth of the algae in the inner structure of the geotextile would difficult their extraction, but previous text in our laboratory using high pressure water jet has proved successful for a successfully use to harvest this algal biomass when this geotextile is fixed to vertical panels. The use of a layer of biochar as a support also increases the growth of algae between 7-9%; this would be another possibility if the final destination of algal biomass is their agronomic application; biochar is currently used as a soil amendment due to its good adsorptive capacity, the presence of internal cavities therefore contributing improved soil physical structure, the slow release of nutrients, and associated increases in soil recalcitrant organic C contents. Images obtained by SEM of this biochar after algal growth showed superficial colonization of the biochar. One potential drawbacks of this technique is the presence of contaminants, such as PAHs, in the biochar which could inhibit algal growth; in a parallel test, a biochar produced through a low temperature pyrolysis process (<300 °C) was discarded due to its strong inhibiting of algal growth.

KEYWORDS: *Anabaena*, *Klebsormidium*, solid support, algae growth, biochar.

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Topic 4

Energy and climate change

RELIABILITY OF SELF-EXCITED INDUCTION GENERATOR FOR WIND ENERGY CONVERSION

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INTRODUCTION

The continuing decline in prices of generators based on renewable energy and the increasing reliability of these systems led to greater use of decentralized energy sources, namely the systems of self-excited induction generators for wind energy conversion in isolated sites.

The use of renewable energy sources to optimize maximum power generation systems, both from a technical and an economical point of view. The new technological solutions offered by these systems present by against a considerable evident interest by their unbeatable flexibility, their flexibility of functioning and their cost.

A renewable energy sources system must:

Ensure at all times the sufficient energy required by the load. Rely on an automated management of system components in order to ensure the stability of the system at all times.

However these installations requires a study of their reliability to determine the different technological solutions to better ensure the continuity of the electricity production and this regardless the daily consumption peaks or the weather conditions that affect the energy production and master both fundamental constraints of operating a power gr

1. The voltage level at every point of the network, remain near its nominal value.

2. The frequency of the voltage wave must be stable and close to its nominal value.

In this context, the work presented in this article is the contribution to the study of the reliability of a system of representative bodies of renewable energy sources, to define an ideal operation of the system to ensure its stability at all times, including in the transitions between the different modes of operation . From a technological point of view, the reliability is not just a matter of compliance to the electricity supply, but also the maintenance and the dependability of the system, often including the particular conditions of isolated sites [1].

MAIN RESULTS

-Isolated Wind Turbine Modeling System

$$P_{\max} = \left(\frac{16}{27}\right) \cdot \left(\frac{1}{2}\right) \cdot \rho \cdot S \cdot V_1^3$$

-Model of the self-excited induction generator

$$V_{sd} = R_s \cdot i_{sd} + \frac{d\varphi_{sd}}{dt} - w_s \cdot \varphi_{sq}$$

$$V_{sq} = R_s \cdot i_{sq} + \frac{d\varphi_{sq}}{dt} - w_s \cdot \varphi_{sd}$$

The first step of a reliability analysis consists of making a deep study of the system. A common approach is to perform a " Failure Mode and Effects Analysis " (FMEA).

The reliability R (t) of the installation :

$$R(t) = \prod_{i=1}^{i=N} R_i$$

$$R(t) = R_{E1}(t) \cdot R_{E2}(t) \cdot R_{E3}(t) \cdot R_{E4}(t)$$

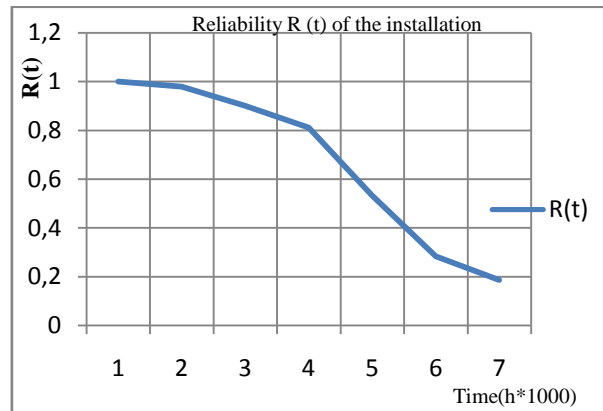


Figure 1: Graph of the reliability of the installation

CONCLUSION

In this article, we presented different stages of the study of how an self-excited induction generators system a renewable energy source, by an autonomous regime for supplying the isolated sites. However these facilities requires a study of their reliability, with the objective to maintain a high level of reliability with a minimal cost thanks to an optimal dimensioning of systems to ensure the sufficient energy required by the load at all times, and to determine the various technological solutions to better ensure the continuity of the electricity production and regardless daily peaks of the consumption or the weather conditions that affect the energy production

and master the fundamental constraints of operating of an isolated electricity network, this leads us to conclude that the reliability of an system is not only a matter of respect of the norms for electricity supply, but also the maintenance and the safety of the system operating, often taking account of the specific conditions of the isolated sites.

Keywords: Reliability, Self-excited induction Generator, Wind turbine, Renewable energy.

ALTERNATIVE FUEL: IMPACT OF BURNING POMACE ON TEMPERATURE PROFILE OCCURRING IN THE ROTARY CEMENT KILN

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The cement industry is one of the major sectors energy consuming. Typically for producing one ton of cement, a well-equipped plant consumes nearly 3 GJ.

The cement industry has a significant interest in replacing fossil fuels with alternative fuels in order to minimize production costs and reduce CO₂ emissions. These new alternative fuels (AF) are in particular solid fuels such as refuse derived fuel, tire-derived fuel (TDF), waste wood and pomace olive residue. Solid alternative fuels typically have physical and chemical properties that differ from traditional solid fossil fuels. The substitution rate of alternative fuels vary significantly according to the type and composition of AF. Alternative fuels may differ typically in physical and chemical properties compared to the usual fossil fuels.

In this paper, we discuss and evaluate the fact of using olive pomace as alternative fuel on temperature profile occurring in cement kiln. A comprehensive one-dimensional model was developed to simulate complex processes occurring in rotary cement kilns. In this work, separate models were developed, viz: model for simulating reactions and heat transfer in the bed region, a model for simulating combustion and heat transfer in the freeboard region. These two models were solved with a segregated solution approach and were coupled to each other, along with a model for bed height via mass and energy communication through common boundaries.

Mathematical resolution of the combustion model indicates that the calculated gas temperature profile agreed with the results reported in the literature and data from the real scale, this result confirms the ability to use olive pomace as alternative fuel. On the other hand the results show that the model was able to predict one of the rotary kiln process key factors.

KEYWORDS: combustion; alternative fuel; rotary kiln; heat transfer; ...

ANALYSIS OF THE EFFECT OF AN OBSTACLE ON THE EXTRACTABLE WIND ENERGY

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To implement a wind farm, preliminary estimation of wind turbine production is required. This corresponds to the extractable energy in a given period of operation for a given wind turbine configuration and location. To evaluate the amount of wind farm energy, it is necessary to have the accurate height distribution of wind speeds on that location. It is well known that the wind farm performance depends on the characteristics of the air flow as well as the actual atmospheric boundary layer. This varies according to the thermal stability condition, the roughness of the ground and the site topography.

The wind farm performance could also be perturbed by the presence of a variety of obstacles. In this study, a 2D model describing the atmospheric circulations that are induced by the presence of an obstacle having the form of a hill was developed. The hill profile was schematized by a half circle curve. The turbulent air flow was modeled by the Navier-Stokes equations and the $k-\varepsilon$ turbulence model. The boundary conditions at the ground level were described by a wall law. The other boundary conditions correspond to a logarithmic velocity profile input, a uniform speed on the upper contour of the domain and a uniform pressure in the outlet area.

Computational fluid dynamics (CFD) was performed by using the finite element under COMSOL software package. Accuracy of the model was discussed as function of the location of the boundary fixing the truncated computational domain and the mesh size used.

The obtained results were compared to those of a flat soil without obstacles. A drastic reduction of the extractable energy was found to occur if the wind turbine is placed arbitrarily downwards of the hill obstacle. We concluded that the presence several obstacles on flat soil show an important effect on wind received also the $K-\varepsilon$ model made a complete description of the velocity profile around the hill given.

KEYWORDS: Wind energy; air flow; hill obstacle; CFD, velocity profile.

NUMERICAL ANALYSIS OF HEAT TRANSFER BEHAVIOR OF A RECTANGULAR HEAT EXCHANGER: AIR-PHASE CHANGE MATERIAL

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INTRODUCTION

The storage of solar energy in the form of latent heat in Phase Change Materials (PCM) is one of the most promising ways to generate electricity [1] at night or for building heating in winter [2,3], which reduces energy consumption and correlatively contributes to the environment protection.

This work is concerned with the exploitation of solar energy in the buildings by an actively system [4] which consists of an exchanger-storage device containing a PCM and using air as heat transfer fluid (HTF). PCM considered in this study is C18 paraffin with a phase change temperature range of [28-28.5 ° C]. The system studied is a rectangular heat exchanger air-PCM (Figure 1). PCM module is 6 cm thick and the square channel air flow has a 4 cm core height. The entire channel length is 1.2m.

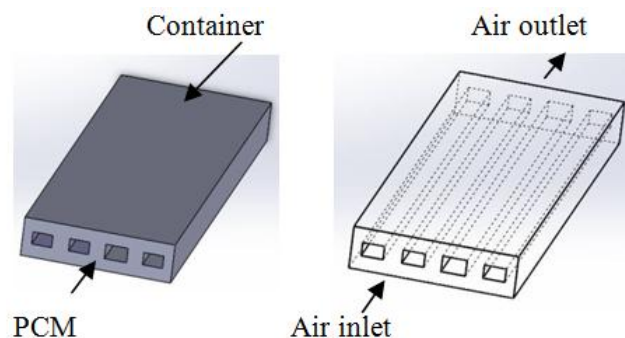


Figure 1: Scheme of the studied exchanger

The main objective of this work is to improve understanding of the convective heat transfer phenomenon in the PCM to optimize controller parameters during storage and heat delivery phases. In this perspective, a numerical model based on finite volume method was conducted to control the solidification front of the PCM under different operation conditions.

The modeling of the thermoconvective flow in the PCM domain is based on Navier-Stokes equations formulated in 3D rectangular coordinates. Solidification is taken into account by introducing in momentum equations an attenuation term of the velocity components according to the liquid fraction [5].

NUMERICAL RESULTS

To highlight the effect of natural convection on the heat transfer rate, we compared the solidification time obtained by assuming, in first calculation, that heat transfer in PCM is purely conductive, and in a second calculation, we take into account the natural convection. This comparison indicates that the air outlet temperature in this second case is smaller by about 30%. Hence, it appears that the hypothesis that natural convection can be neglected is not justified.

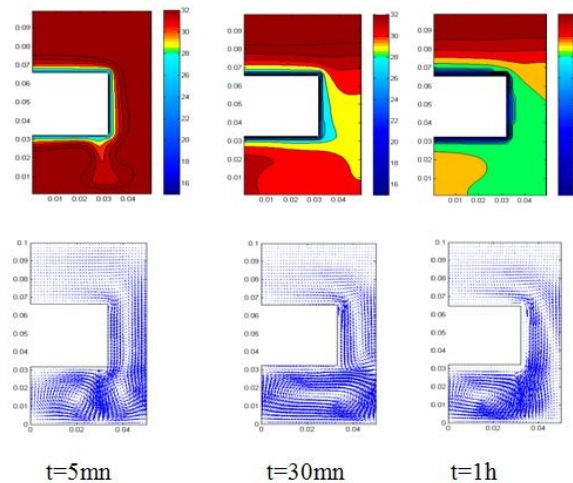


Figure 2: Temporal evolution of the temperature fields and corresponding velocity vectors.

The transient natural convection heat transfer in a rectangular air-PCM heat exchanger is considered in the present section. Figure 3 shows the temporal evolution of velocity and temperature distributions in the PCM domain after 5 min, 30 and 1 hour successively. These results are shown in a cross section corresponding to 1m from the air inlet.

As can be seen, at the beginning, the liquid develops a thermal gradient on the sides of the channel. The fluid surrounding the cooled PCM adjacent to the channel walls becomes denser and tends to fall downwards. The interior preheated fluid then moves to replace this cooled PCM and hence forms a rising convection current, leading to the growth of multicellular thermal patterns.

CONCLUSION

The present work is interested in the PCM (Paraffin C18) solidification in thermal storage rectangular air-PCM heat exchanger used for heating buildings by solar energy. This numerical approach aims at studying the impact of the natural convection, occurring in the liquid phase on the solidification time of PCM and the temporal evolution of the solidification front.

References

- [1] M.Bianchi, Applied Energy, 88(5) (2011), 1500–1509.
- [2] F. Kuznik, et al., Renewable and Sustainable Energy Reviews. 15 (2011) 379–391.
- [3] V.V. Tyagi, et al., Renewable and Sustainable Energy Reviews. 15 (2011) 1373–1391.
- [4] I. JMAL, M. BACCAR, Applied Thermal Engineering; (2015), 84, 320-330.
- [5] A. D. Brent, et al., Numerical Heat Transfer. (1988) 13, 297–318.

STUDY AND SIMULATION OF SEVERAL MODELS OF PHOTOVOLTAIC MODULE IN MATLAB

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Solar energy plays an important role in the production of clean energy and the core of solar power generation system is a solar cells. These solar cells convert photon energy into electrical energy using photovoltaic effect and are made up of p-n semiconductor junctions.

Modeling of solar cell is necessarily for the prediction of the behavior of a real solar cell under various environmental conditions and further to obtain its current-voltage (I-V) and power-voltage (P-V) characteristic curves.

We have different kinds of solar cell models and these models presented in several papers like single-diode model, two-diode model, three diode models, model with partial shading considerations and much more. The most commonly used models are single diode and two diode model, as they provide better relations with a practical solar cell keeping in mind the simplicity and the speed in the extraction of parameters as well as I-V and P-V curves also gives minimum error.

In this paper we study and simulate three different models of solar cell: Ideal Single Diode Model, Practical Single Diode Model, Two Diode Model, these models are developed and implemented in Simulink, their I-V characteristics are compared with the experimentally obtained characteristics for accuracy of the model. In addition to it, various other characteristics of the cell, namely, P-V characteristics for varying temperatures, and solar irradiation levels are also tested.

KEYWORDS: photovoltaic; Solar cell; Matlab; Two-diode; Single-diode.

REALIZATION OF DYE-SENSITIZED SOLAR CELL

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Today, silicon photovoltaic cells dominate the market with over 90% of sales. These cells, referred to as first-generation solar cells, are made of inorganic material and, beyond the improvement of performances in terms of reliability and efficiency of photovoltaic devices, the challenge is to significantly reduce the cost of manufacturing cells. To do this, replace the inorganic material (silicon) by other organic materials, easy to implement, is a very promising solution although technological hurdles remain to be overcome.

In this context, we propose in our work a realization of a dye solar cell (or DSSC for « Dye Sensitized Solar Cell »). This type of cell uses organic dyes to produce photocurrent. Michael Grätzel of the Swiss Federal Polytechnic School in Lausanne achieved the first prototype of these cells.



Fig 1. Test of the voltage supplied by the solar cell

The working principle of a DSSC is very simple. To make our cell in a laboratory, we divided our work into two main parts:

- At first, after having highlighted the problems facing us in the development of electrodes, we vary methods (gold thin layer deposition, conductive glass realization) and different settings to make them and having a good electrical conductivity coupled with optimum anode transparency.
- In a second step, after the preparation of the different layers that, the cell will contain (TiO_2 as a semiconductor, dye, and the electrolyte); we assembled the cell and have tested it.

The solar cell that we realized represents a preliminary step to improve the development of this type of cells in our laboratory. Tests carried out have demonstrated the advantages and limitations of our experimental process, especially on the side of the anode. These results allowed us to reflect and develop other strategies for the future of our work in this area.

KEYWORDS: Solar cell, DSSC, photovoltaic, dye, Grätzel

IN THE UPDATING OF ALGERIAN MAPS OF SOLAR RADIATION, AND STUDY OF ITS COMPLEMENTARITY WITH WIND ENERGY IN ALGERIA

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The sharp increase in oil prices that occurred in 1973 pushed the man to look for other sources of energy. In Algeria, even if their opinions differ wanting agree on a specific date, all the experts are unanimous in saying that will come a day when the depletion of fossil resources will be inevitable.

One of the answers to this problem lies in the use of energy called "renewable". The latter, in addition to being more respectful of the nature, are also known to be inexhaustible during human time scale, which is not the case with fossil fuels. Among the most promising renewable sources in Algeria, we find solar energy in first position, followed by wind energy. Indeed, the first published work by Said et al in 1984, Benssad in 1985, Hammouche in 1990, KasbadjiMerzouk in 2000 and Sidi Mohamed in 2012, showed that Algeria had a large wind resource whose exploitation is very interesting. Moreover, with a duration of sunshine up to 3900 hours/year (Highlands and Sahara), Algeria is considered as the country with the largest solar potential of the entire Mediterranean basin.

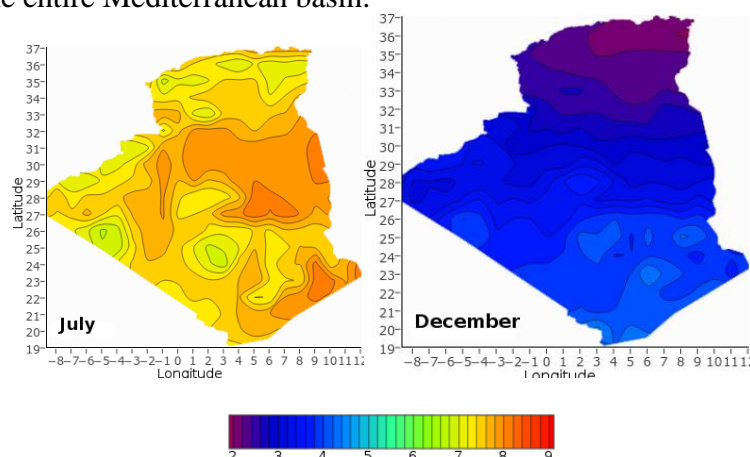


Fig 1. Examples of the realized solar maps (kW/m² day)

The exploitation of these sources appears to be the right solution to meet concerns related to the massive use of fossil sources. However, intermittency of solar and wind energies can cause cuts in the production of energy. Because of this, the concept of "hybrid system" was introduced (coupling two power sources within a production system). In this context, after having contributed to the updating of solar maps of Algeria, we quantitatively analyzed the solar and wind energy potential available to several regions of the country. Then, taking advantage of the collected meteorological data, we studied the intensity of the relationship that may exist between the temporal variations of these two renewable sources, and this using the Pearson correlation coefficient, and energy complementarity. We finished our study by analyzing the energy complementarity.

KEYWORDS: Solar energy, wind energy, hybrid system, Algeria, temporal complementarity

OPTIMAL MANAGING AND SIZING OF A PUMPED HYDRO STORAGE FOR WIND POWER

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As wind energy is increasingly integrated to power systems, new challenges have been brought to the system operations due to its high variability and low predictability. One solution to overcome this problem consists in coordinate wind and hydro generation by adding a pumped hydro Storage. Thus increasing the systems flexibility and profitability.

The concept of a pumped hydro storage relies upon an upper and lower water reservoir. Water is pumped from the lower reservoir to the upper reservoir during periods of low demand and therefore low price, typically at night. When demand and prices are high, the water is allowed to flow back down the system through turbines to generate electricity.

This article presents methods to calculate the best operation and sizing of energy storage for a wind power plant. An hourly optimization problem was formulated to achieve maximum gain and to determine optimal operating strategies for the system. A method of storage sizing in terms of energy capacity and power capacity is also proposed.

The operations of a wind-hydro plant are modeled as a constrained linear programming optimization problem where the objective is to increase the economic benefits that results from the energy delivered to the grid using price and wind forecasts for 24 hours ahead and considering the main operational restrictions of the hybrid system. The solution of the model which is not presented here, provides hourly active power to be generated by the hydro and wind generators during each of the 24 hours, storage levels and pump operational strategy in the period.

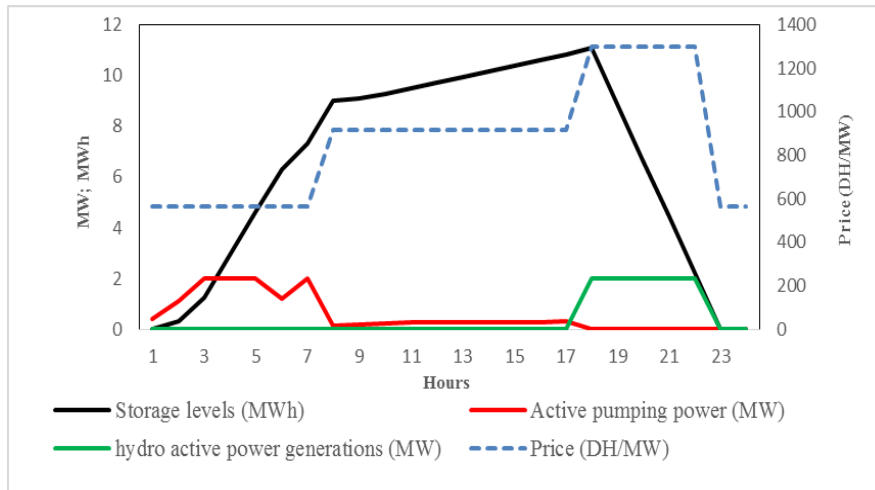


Fig.1: Optimization results

Storage operations of an 11MW wind park are illustrated in Fig.1. The pump unit takes advantage of the lower price periods to pump water into the reservoir. Then, when high price time occurs the hydro power plant generates energy from the stored water. In this study, the hydro-wind operation plant increases the profit in 14.8%. Assuming the same operating conditions during all the year, the annual gain could reach around 5478311 DH.

The storage sizing problem is performed by a nonlinear programming algorithm given the farm production power, the load power, the efficiencies of pumping and generating, and taking into account the energy restrictions on the farm. The primary problem variables are the energy capacity and the power capacity of the pumped hydro station. This sizing model aims to minimize the total daily cost of the storage while being able to meet the demand. Many constraints used in the previous problem have been kept and new ones related the power balance have been added. Results from our case study shows that the total load is met by the wind farm and the energy storage.

As a conclusion, optimization approaches were developed to identify the best combined daily operational strategy and sizing of a wind and hydro pumped storage system. The first model allows an increase in wind farm profit, since wind energy is principally delivered to the grid during high price hours. The focus of the second problem is to determine the optimal storage sizing with respect to the installation cost.

KEYWORDS: Wind power, pumped storage, optimal operation, sizing.

EXPERIMENTAL STUDY AND NUMERICAL MODELLING OF DRYING CHARACTERISTICS OF STEVIA (*STEVIA REBAUDIANABERTONI*) LEAVES

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In countries like Morocco, which produce sugar from sugar beet or sugar cane in inadequate quantities, it is recommended to evaluate many alternative sweeteners as sugar substitutes. There are many natural and synthetic sweeteners. However, these latter have been shown currently to be carcinogenic thus *Stevia rebaudiana*Bertoni is an alternative to sucrose and other synthetic sweeteners with the advantage that stevia is natural sweetener.

*Stevia rebaudiana*Bertoni is a small bush plant native to Paraguay. Its leaves contain approximately 10% steviolosides which are intensely sweet compounds (150 to 300 times sweeter than sugar).

Due to the sweetness and supposed therapeutic properties of its leaf, *S. rebaudiana*Bertoni has attracted economic and scientific interests. Today its cultivation has spread to other regions of the world, including Canada and some parts of Asia, Europe and Morocco. In Morocco, its culture was officially introduced for the first time in 2008.

Like other medicinal and aromatic plants, *Stevia* leaves need to be dried for conservation and consumption purposes. Moreover, drying process is one of the most important activities in postharvest handling of *stevia*, it is useful to preserve quality and stability of this plant.

Several studies involved the usefulness of *stevia*, its compositions and biologic and therapeutic effects. However, there is no scientific report about drying characteristics of *stevia* leaves in Morocco.

The aim of this work is to study the solar drying kinetics of *Stevia rebaudiana* Bertoni leaves. An indirect forced convective solar dryer is used and the effect of air temperature on the experimental drying of *stevia* leaf kinetics is examined.

The kinetics drying is studied for four temperatures (50, 60, 70 and 80 °C) and for two air flows drying (150 and 300 m³.h⁻¹).

A mathematical treatment of experimental data was applied for describing drying curves, fitting the experimental variations of moisture ratios versus drying time by using four empirical equations chosen in the literature and to determining the corresponding characteristic drying curve (CDC). The drying speed was determined then empirically from the characteristic drying curve. Analytical solution of Fick's equation was used in order to estimate apparent moisture diffusivity of the *stevia* leaves.

The solar drying for preservation of food products is the most attractive and promising application, it leads to reduce the water activity in the product and thereby prolongs its shelf life. Moreover, the use of renewable energy, solar drying could be a good option to reduce drying costs and contribute to better management of environmental issues.

KEYWORDS: Characteristic drying curve; Drying curves; Modeling; Solar drying; *Stevia rebaudiana* Bertoni leaves

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Ministry of Higher Education, Scientific Research and Professional training of Morocco- Rabat, Priority Research Program (PPR –B –Mahrouz–FS–UCA–Marrakech) and Mr Omar EL HROD from MOGADOR Cooperative (ESSAOUIRA, Morocco) for assistance during sampling of plant material.

RECOVERY HEAT LOSS OF A POTTERY KILN

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INTRODUCTION

The craft industry is considered among the main economic activities in Morocco. Pottery based mainly on clay, is country's heritage.

The objective of this work is the study of the thermal behavior of a kiln used for baking pottery pieces, in order to optimize the energy consumption to meet Morocco's commitments under the conventions climate change.

MAIN RESULTS

The useful energy for the pottery is composed of:

- A sensible heat to bring the clay mass from the initial temperature at the final temperature;
- A latent heat to evaporate the water mass at 100°C ;
- A sensitive heat to bring the mass of water from 100°C to the final temperature.

The heat from the burners [1] is given by:

$$Q_C = PCI * \text{Mass flow} \quad (1)$$

The burners produce a high velocity flame which gives an important heat exchange and a uniform temperature in the furnace [2].

The PCI is the heat of combustion of the combustible gas which is the enthalpy of reaction [3].

The heat (Q_c) transmitted by the fuel turns into: - useful heat (Q_u) to the products and - heat losses (Q_{parois}) to the environment (combustion gas leaving through the chimney and heat transmitted from the furnace walls).

Several studies have shown that the chimney loss can reach 65% [1].

Heat losses through the furnace walls are given by:

$$q_k = \frac{\Delta T}{\sum R_k} \quad (2)$$

ΔT is the temperature potential in the walls;

$\sum R_k$ is the thermal resistance of the wall.

Table 1 provides the combustion energy, the useful energy, the lost energy and their percentages.

TABLE 1: COMBUSTION ENERGY, USEFUL ENERGY, LOST ENERGY AND THEIR PERCENTAGES

	Combustion energy (MJ)	Useful energy (MJ)	Lost energy (MJ)	
			Through furnace walls	through chimney
	3817,145	139,41	1680,05	1997,69
%	100%	4%	44%	52%

To explore the possibility of energy recovery, a numerical model was developed to calculate losses through the furnace walls in order to determine the chimney losses.

The modeling is based on the transfer of heat through the wall of the kiln.

$$\frac{\partial}{\partial x} (k \frac{\partial T}{\partial x}) = \rho c \frac{\partial T}{\partial t} \quad (3)$$

The following equations give the thermal conductivity as a function of temperature [4]:

Ceramic fiber:

$$K(T) = 0.10704 * e^{0.00016 * T(x)} \quad (4)$$

Rock wool:

$$K(T) = 0.0557 * \log(T(x)) - 0.2769 \quad (5)$$

The figure representing experimentally measured temperatures and those obtained by the program shows a good agreement.

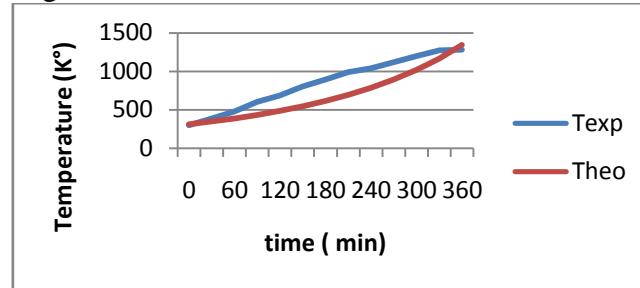


Figure 1: Experimental temperature values (T_{exp}) & Theoretical (T_{theo})

Fig.1 shows the comparison between the results obtained experimentally and the ones obtained numerically. We can note the good correlation between the two ways. This will lead us perform numerically without using expensive material.

CONCLUSION

The experimental study of the gas furnace for pottery shows that the losses through the chimney exceed 50%.

To investigate the possibility of recovering this heat supplied to the furnace by the combustion gases, a numerical model was developed.

This numerical model has been validated by comparing the experimental values of temperature inside the kiln with those computed by the model.

References

- [1] Series of energy management "Ovens, dryers and kilns", Energy and Resources, Canada.
- [2] L. Balli, A. Touzani, "Experimental Study and modeling of heat exchange in four to Pottery", TERMOTEHNICA, VOL. 1/2014.
- [3] Industrial Chemistry, Volume 2.
- [4] Superwool plus Insulating Fiber.

NUMERICAL STUDY OF THE OLIVE POMACE DRYING

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This research investigation has been conducted within the framework of VERA project supported by the "Region Centre Val de Loire, France". It aims to optimize an integrated process for energy recovery from agricultural waste, including olive pomace. This product is obtained from the extraction of olive oil and it mainly consists of solid residue and an important quantity of water which represents 20-50% of the total weight of the processed olives. The disposal of this waste without any treatment causes serious environmental problems. But, it could be used as: a fertilizer, an animal feed and for energy generation. We note that the burning of this biomass for the heat generation is targeted by the VERA project in order to electricity production. Before starting the combustion step, the olive pomace waste must be dried. This operation concerns the rationalizing the consumption of energy required especially when solar drying is used.

This study has been focused on the mathematical modeling of olive pomace drying in a convective solar dryer. This parallelepiped shape system is thermally insulated and it is essentially composed of several trays horizontally arranged to receive the drying air from which the dryer is fed. This air is coming from a solar thermal collector perpendicular to the racks, in the upward direction through the product to dry (olive pomace).

The differential equations system which describes the heat and mass transfer between different elements of the dryer (product, hot air and drying chamber), is numerically solved using a finite difference method and taking into account the appropriate boundary and initial conditions. In order to validate the proposed model, the obtained numerical results have been compared to the experimental results found in the literature. It was concluded that the agreement is generally acceptable.

KEYWORDS: mathematical modeling; moisture content; olive pomace; drying.

STORAGE / RECOVERY OF THE THERMAL ENERGY BY LATENT HEAT IN A PHASE CHANGE MATERIALS DURING THE MELTING AND SOLIDIFICATION USING A CYLINDRICAL SYSTEM

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Global warming and the depletion of fossil energy sources leads to propose new solutions that consume less energy and cleaner than current methods. To limit consumption, the thermal energy storage (TES) is a possible solution; the fundamental purpose of a TES system is to facilitate energy management by storing thermal energy at periods when it is abundantly available and then using it when and where it is required. The use of phase change materials (PCMs) to store and release large quantities of heat with small volumes using the latent heat storage during melting and solidification at specific temperatures. Due to their thermal regulator function, The PCMs are used in different applications such as heating and cooling passive solar or thermal batteries. Integrated into the building envelope, the PCMs allow a better use of solar energy and minimize temperature fluctuations by changing solid-liquid phase.

This experimental work concern two concentric tubes used as an energy storage element by latent heat generated by melting a phase change material (PCM) at low temperature. The annular space of these tubes is filled with paraffin as PCM which is characterized by a melting temperature of 56 °C. PCM material it is heated by using water as HTF. Water circulates upward flow in the inner tube and, the circulation is caused by a variable flow pump. The temperature variations during melting or solidifying is followed by using fourteen K-type thermocouples integrated in the experimental device developed in our laboratory at different positions including the inlet and outlet heat transfer fluid.

Experimental results show the influence of the HTF flow rate on the charging and discharging processes of the PCM.

KEYWORDS: Latent heat; Phase Change Material; Thermal Energy Storage; Heat Transfert Fluid.

THE IMPACT OF SOLAR RADIATION ON THE OPERATING CELL SOLAR TEMPERATURE

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The objective of this work is the study of the meteorological parameters having an influence on the electric productivity of a photovoltaic installation. we present a numerical simulation of local solar radiation and the annual and seasonal optimum exposure of the photovoltaic modules to large Casablanca regions «This study is conducted for the Mohammedia city», finally we will discuss an experimental study carried on the Solar Platform of Cadarache-frensh to explain the thermal behavior of a photovoltaic solar cell, and the impact of changes in local meteorological parameters on the operating temperature of a photovoltaic solar cell

First, we give the method of simulation performed by MATLAB which significantly explains the variation of different equatorial and horizontal coordinates for determining the position of the sun in the celestial sphere, We will then outline the design of solar radiation received on a 1m² surface and daily, monthly and annual variations of solar energy in the city of Mohammedia in latitude 33 ° 41'09 "and Longitude 7 ° 22 ' 58 ".

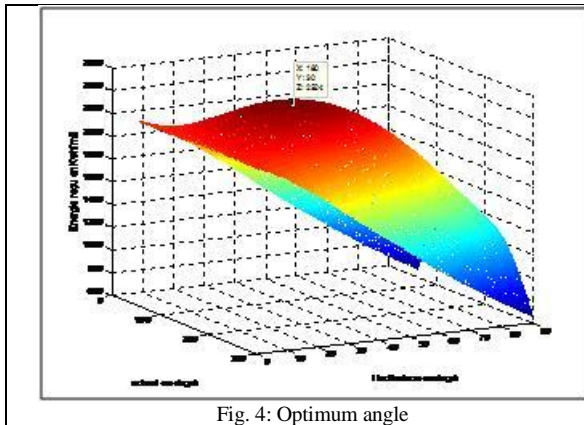


Fig. 4: Optimum angle

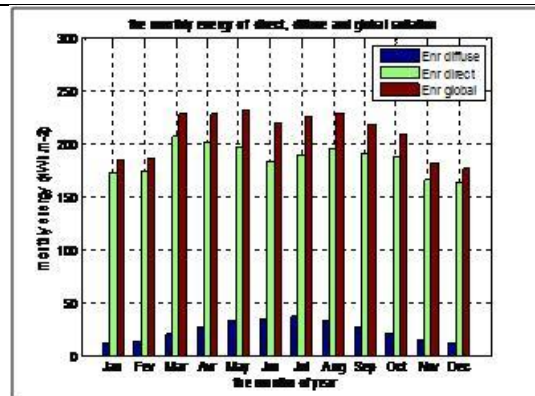


Fig. 2: the monthly energy of direct, diffuse and global radiation

At the end of interpreting the our results on the City of Mohammedia, we found such results; the optimal inclination is 30° degrees and azimuth 180 ° (south) that captured 2524Kwh / m² of energy per year.

Finally, we will provide in a final step an example that treats the thermal behavior of a photovoltaic module from the influence of the illumination of solar radiation, ambient temperature and wind speed on the module operating temperature.

We have found that the illumination of solar radiation, ambient temperature and wind speed are meteorological variables that mostly influence the thermal exchange between the solar module and their environment.

KEYWORDS: photovoltaic; solar radiation; ambient temperature; wind speed; thermal behavior

OPTICAL PROPERTIES OF ZNO THIN FILMS PREPARED BY SOL-GEL METHOD WITH DIFFERENT THICKNESS.

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The transparent conductive oxides (TCO) are widely used in numerous fields and industries. Dual ownership TCO, electrical conductivity and transparency in the visible, making those ideal candidates for applications in optoelectronics, photovoltaic, or as sensor. ZnO is used for his less expensive cost.

ZnO films are produced by different methods, RF magnetron sputtering, pulsed laser deposition, evaporation by electron beam, the molecular beam epitaxy, chemical vapor deposition, spray pyrolysis, sol- gel, and others. Compared to other methods, a sol-gel process is simple, low cost because it does not require the use of complicated and expensive equipment.

This process offers the possibility to produce films at relatively low temperatures. Moreover, it is an easy way to control the concentration of the solution, the doping level, the homogeneity; heat treatment of the layers is necessary to ensure the complete removal of used solvent. The films obtained are consistent with a high purity.



Fig 1. Different deposits

In this work, Zinc acetate dehydrate was used as the precursor material. ZnO solution was prepared by sol-gel process and deposited by the spin coating method on glass substrates to get the thin films with different thickness. This films were sustained the thermal annealing with tube furnace at various temperatures (50°C to 450°C) to evaporate the solvents.

The optical analyses show that with the increase of film thickness, both the refractive index and ultraviolet emission intensity are improved. However, the transmittance in the visible range is hardly influenced by the film thickness, and the averages are all above 80%.

KEYWORDS: Zinc Oxide; Sol-Gel; spin coating; thin films; Spectrophotometer UV-Visible; Ellipsometry, tube furnaces.

GOLD SPUTTER DEPOSITION (PVD) ON GLASS SUBSTRATES, AND OPTICAL CHARACTERIZATION

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The sputtering method is a deposition technique of thin layers belonging to the PVD family (Physical vapor deposition). It allows synthesizing several materials from the condensation of metallic vapor on a substrate. This phenomenon was highlighted in 1852 by W.R. Grove, and was originally used to deposit thin layers of metal, used as optical reflectors. Since, this method has proven its usefulness for many other applications that exploit the very diverse properties of the deposited thin films:

- Al and Au thin layers were deposited for connectors in integrated circuits.
- Fe, Co and Au for layers with magnetic properties.
- Al and Ag as optical reflectors layers.
- Cr layers with a high resistance to corrosion.
- Decorative layers of different compositions.



Fig 1. SCANCOAT SIX SEM SPUTTER COATER

Our goal through this work is to develop transparent conductive substrates. For this, we decided to use sputtering method to deposit thin layers of gold on glass slides.

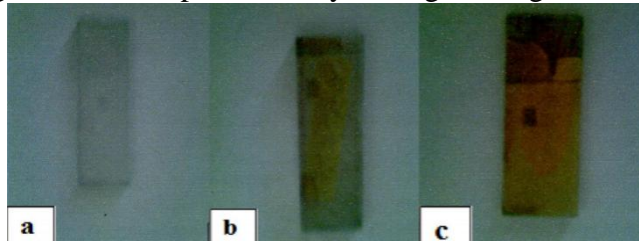


Fig 2. (a) no deposit, (b) 1st deposit (HT = 7, T = 5min), (c) 2nd deposit (HT = 7, T = 5min)

Before moving to the deposit, we must pass through the cleaning step. This step is very important; it makes it possible to remove all traces of dust and grease, and ensures that the substrate surface has no defects of flatness or scratches. These conditions are essential for good adhesion and uniformity of thin film deposition. The substrates are cleaned using the following steps:

- Bath in acetone for 10 min.
- Bath in isopropanol for 10 min.
- Rinsing with deionized water 10 min.
- Stoving at 100 ° C for 5 min.

The machine used for the deposit is the model "SCANCOAT SIX SEM SPUTTER COATER"(Figure 1). By varying two of its basic parameters, the high voltage value and the deposit time, we conducted many deposits on rectangular glass samples (40 × 20mm) (Figure 2). To choose the best deposition, which provides, at the same time, good electrical conductivity coupled to an excellent light transmission, we analyze our samples with a spectrophotometer and we tested the electrical conduction provided by the surfaces of the substrates, which have undergone a deposit. The results were conclusive.

In conclusion, we can say that our study allowed us to see some practical applications for the deposit used technique. The transparent conductive substrates that we have obtained can be used in many areas, we quote one of their applications in photovoltaic technology field, and that is their use as electrodes for dye solar cells (Grätzel cells), application that is part of our research focus.

KEYWORDS: PVD, gold, sputter deposition, optical characterization, conductive glass

CALCULATION OF COST AND OPTIMIZATION OF THE SIZING OF A PHOTOVOLTAIC INSTALLATION BASED ON THE SOLAR UTILISABILITY FUNCTION. APPLICATION IN TLEMCCEN, ALGERIA

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In developing countries, where the infrastructure for the distribution of electrical energy is not very developed, especially in rural and isolated areas, the production of electric energy thanks to photovoltaic systems is an increasingly promising option.

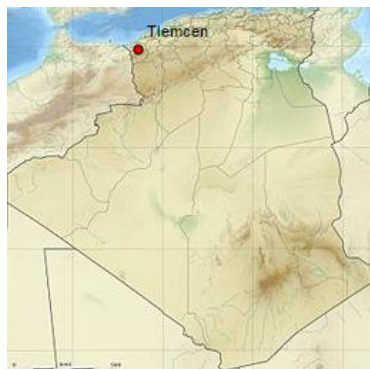


Fig 1. Localization of Tlemcen

Despite the maturity experienced by the renewable energy sector, sizing photovoltaic systems still pose many problems. In our study, we examine this question trying to optimize the capturing surface of photovoltaic panels, and the total storage capacity of the batteries. This optimization is performed vis-à-vis the available meteorological data, the criteria chosen by the user, and the overall economic cost.

We have divided the year into three distinct periods (see hourly load demand curve in Figure 2):

- Warm Period: May, June, July and August.
- Sweet Period: March, April, September and October.
- Cold Period: November, December, January and February.

The used method is based on the concept of solar utilisability function, a concept that does not poses many restrictions in terms of system design or distribution of the load over time. We applied our study to an autonomous photovoltaic system based in Tlemcen, North-west of Algeria (Figure 1)

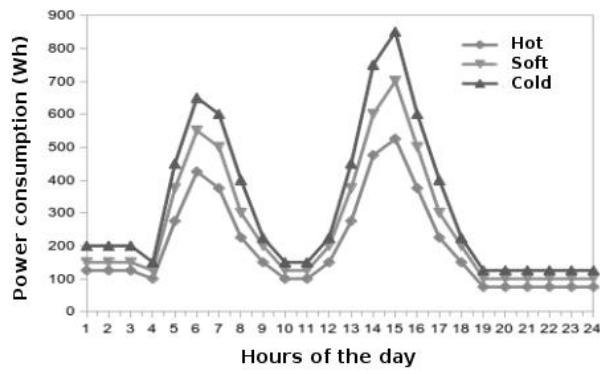


Fig 2. Hourly load demand curve

KEYWORDS: Solar energy, photovoltaic, utilisability function, stand-alone system, Algeria

UPDATING THE EVALUATION OF SOLAR POTENTIAL, AND OPTIMIZATION OF STAND ALONE PHOTOVOLTAIC SYSTEMBASED IN NORTHERN ALGERIA

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The analysis of any system producing energy requires that we take into account the different parameters and variables that affect its operation. Thus, an analysis of the evolution of the production system as a function of these quantities is required. This is usually done using type models "input output"

Above all, as the term "production" is not really suitable when talking about energy, because in reality, we only transform one primary form of energy into another (which is in our study the electricity), we have previously carried out a qualitative and quantitative analysis of primary energy potential of the region where we want to install our production system. In Algeria, in the field of renewable energies, the solar energy is most available across the entire national territory. Many studies were conducted to evaluate the potential of this energy, we, in our work, we suggest, firstly, to contribute to the updating of evaluation of the Algerian solar potential by drawing maps representing this potential for each month of the year.

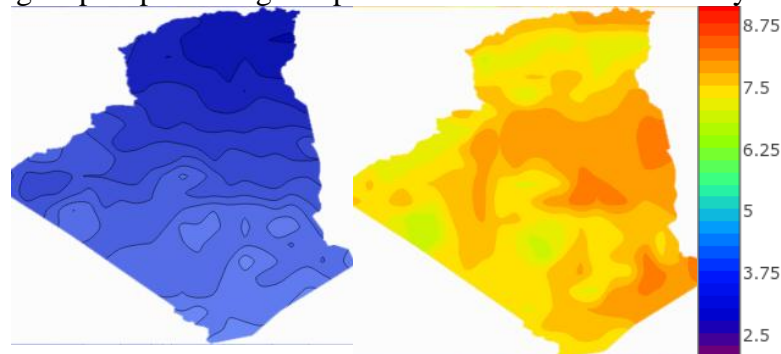


Fig 1. Examples of the realized solar maps (kW/m² day)

Secondly, after exploiting the results obtained in the first part of our work, we will select a northern region of Algeria with high solar potential in order to optimize the design of a photovoltaic installation for the electrical energy supply of an isolated site within this region. With developing a comprehensive mathematical model for solar radiation generating on inclined surface, we will use the hourly solar utilisability function to design the system and manage the different energies through time.

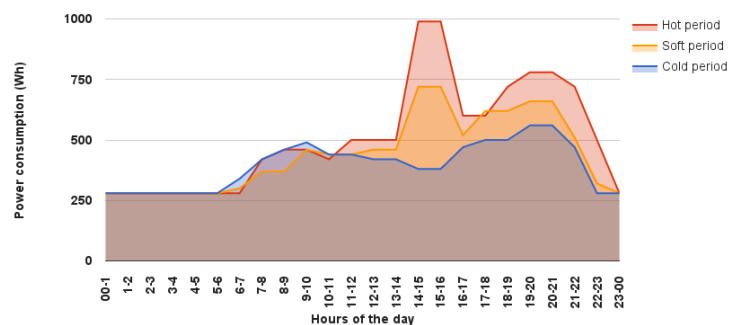


Fig 2. Hourly load demand curve

We have divided the year into three distinct periods (see hourly load demand curve in Figure 1):

- Warm Period: May, June, July and August.
- Sweet Period: March, April, September and October.
- Cold Period: November, December, January and February.

A computer program based on the Python language has been specially developed to optimize the PV system. The Algorithm used is genetic algorithm. The results were conclusive.

KEYWORDS: Solar energy, photovoltaic, stand-alone system, solar utilisability, Algeria

CHARACTERIZATION OF COMBUSTION OF OLIVE POMACE IN A BIOMASS FLUIDIZED BED BOILER.

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As part of the VERA project (Energy Recovery from Agricultural Residues), a biomass fluidized bed boiler was designed and built by the Materials and Renewable Energy Team (EMER) of the Faculty of Science (Meknes) in collaboration with ICARE laboratory (Institute of Combustion Aerothermics, Reactivity and Environment) of the CNRS Orleans.

The biomass boiler designed and built by the VERA team is mainly composed of two separate compartments, one represents the combustion chamber with a grate is centered on the primary air injected by a blower with variable flow. A convergent is deposited on the second compartment, this convergent is connected to the chimney to channel smoke and limit air infiltration. Holes arranged vertically, were drilled in each of the faces of the two compartments to put various sensors (temperature, pressure, etc.) at different heights of the room. Furthermore, the external sides of the room are equipped with tinted glass windows to visualize the flame inside the boiler. Additionally, the chimney is connected to a dust removal system (cyclone) for shutting off the dust carried by the gas from the combustion .These particles are then transported by gravity to the element reserved in the recovery of ash which is below the combustion chamber and to be emptied regularly (figure 1) .

In this work, two types of biomass are analyzed, a crude olive pomace and an olive pomace oil free. The purpose of the experimental measurements is to show how the values of selected combustion parameters vary with the mass flow of air, the mass flow of biomass granulate and the type of olive pomace..Experimentation involves specifically a determination of combustion gas temperature and concentration of gas species. O₂, CO₂, CO, SO_x and NO_x at different positions in the boiler and the flue gas.

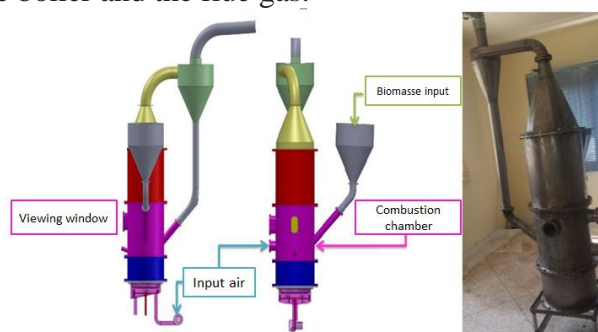


Figure 1: Schematic (left) and picture (right) of boiler.

Keywords: Biomass, Characterization, Combustion, Olive pomace, Fluidized bed boiler.

ENERGETIC POTENTIAL OF SOME ANIMAL AND VEGETAL WASTES

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Co-processing is the use of waste as raw material (without changing the final quality of product), or as a source of energy, or both to replace natural mineral resources (material recycling) and fossil fuels such as coal, petroleum and gas (energy recovery) in industrial processes, mainly in energy intensive industries (EII) such as cement, lime, steel, glass, and power generation. Waste materials used for co-processing are referred to as alternative fuels and raw materials.

This study seeks to evaluate the energetic potential of different kinds of wastes derived from different sources namely (olive residues, sewage sludge and chicken residues, animal meal and fluffy RDF) causing a problem in term of their disposal and management to figure out their feasibility and to estimate their impact on the environment; in Moroccan cement plants through a detailed characterization.

Different decisive parameters promoting the use of wastes as secondary fuels were analyzed: Calorific value, moisture content, volatiles and ash, chlorine, sulfur and trace elements.

The analysis results showed that chicken residue and fluffy RDF have the highest calorific value comparing to olive residues, sewage sludge and animal meals. Compared to coal, all samples have a lower sulfur content which not exceed 1.3%, except animal meal samples. For chlorine content sewage sludge and chicken residues are characterized by lower amount of chlorine compared to olive residues, animal meals and fluffy RDF.

Comparing to the Requirements of cement plant for the main burner, the target samples are perfect for dosing and feeding to the main burner point due to their convenient moisture content which is less than 10%, and calorific value enough to replace a portion of fossil fuels. In term of metal, and through the levels obtained by means of ICP, we can deduct that the majority of metals contained in our samples are presented with quantities smaller than the limit mentioned in the Guideline for the Energetic Recovery of Waste in Cement- Lime and Power plants in North Rhine Westphalia”.

KEYWORDS: Co-processing; Alternative fuels; olive residues; sewage sludge; chicken residues, animal meal and fluffy RDF

RENEWABLE ENERGY & CLIMATE CHANGE IN THE MAGHREB STRATEGY AND VISIONS

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Maghreb countries benefit from sub-humid Mediterranean climate only in a narrow coastal fringe. Thus, they are exposed to Climate disturbances such as the depletion of many natural resources and more exposed to the acceleration of desertification, aridity of the soil and the increased scarcity of water resources. This obliges them to rethink the modes of production and energy consumption, that meanwhile, reveal a significant potential in the energy sector, leading to the use and integration of renewable energies in their energy systems that can assure their development.

Well before the mediatization of the Climate change consequences, the Maghreb countries have implemented strategic orientations to increase water supply through a hydraulic mobilization policy, especially by dams and boreholes and also by reorienting their water management policies, towards a more economic approach which values water use through a tariff regulation of water, the incitement to water-saving irrigation techniques and finally the development of non-conventional water resources.

Thus, in order to face climate change and its veracity, the region must first adapt its energy system and on the other hand, opt for energy solutions with low Carbon Dioxide emissions in order to participate in change climate mitigation efforts.

Energy management options, therefore, remain under-exploited. However, the several realized projects and experiences of some countries in specific sectors demonstrate that RE and EE are plausible options, suitable and advantageous, they may be both considered as CO₂ emission reduction measures as well as adaptation measures to climate change.

This study enrolls in this context and aims to make an inventory of fixtures of the regional, local and territorial approach, linked to renewable energy and climate change in the Maghreb countries. This is to identify the limits of territorial mitigation strategies for the reduction of greenhouse gases (GHG) emissions and adapt to climate change risks in order to define a common strategy in these countries, which will be translated within a concrete program.

KEYWORDS: Maghreb Countries, Renewable Energy, Climate Change, Water Resources, strategies, Greenhouse Gas (GHG)

WASTEWATER SLUDGE SOLAR DRYING: A CASE STUDY IN MARRAKESH, MOROCCO

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Following the rapid pace of construction of wastewater treatment plants in the world, the quantity of municipal sewage sludge is in continuous increase. In recent years, sludge management has become one of the most important issues in waste management owing to the increase in sludge output with the rapid urbanization and the reinforcement of the regulations on its disposal.

The issue raised is a matter of vital interest to all urban and industrial wastewater treatment units and plants. Indeed, it is linked, on the one hand, to the increasing sludge volumes and, secondly, to the disposal problems due to the legislation and regulation, especially in the water, waste and air fields.

At present, different destinations are possible for this type of waste, including: landfill, incineration and agriculture. In each of these cases, the solar sludge drying appears as an essential step that allows a volume reduce factor $X=4$. However, considering the technical, environmental and regulatory constraints, a such sludge disposal is increasingly expensive and complex, and it can be locally challenged or even banned. In arid climate, benefiting mainly of solar energy to minimize the cost of operation, solar drying is used to reduce the mass and the volume of the product and consequently the cost of storage, handling and transport.

The objective of our work is to study the drying kinetic of the sludge from the wastewater treatment plant of Marrakesh, the modeling heat transfer and the experimental greenhouse drying. Experimental campaigns during hot and cold periods were carried out. The results indicated that natural solar drying reduce the moisture content from about 4 Kg water /Kg DS to 0,08 Kg water /Kg DS in hot period and to 0,2 Kg water /Kg DS in cold period in only 72 hours. Furthermore, a large volume reduction representing at least 80% of initial volume was observed in both periods after 72 hours of solar drying process.

The input parameters of the developed model concern the external conditions, the indoor air parameters, the cover characteristics and the sludge parameters. The first simulations have shown that a Runge-Kutta 4 solver module can calculate the unknown parameters, especially the sludge temperature and water content.

The natural solar drying is still subject of intensive experimental studies. The performances of the dryingsystems change through the period of use, the geographical situation of the place where the experimentalwork was done, whatis more itdepends on the origin of the wastewater sludge.

KEYWORDS: Sludge; Kinetic; Solar drying; Wastewater; Arid climate; Marrakesh.

STRAIGHT-LINE THREE STEPS PROCESS FOR BIODIESEL PRODUCTION BY ETHANOLYSIS OF USED FRYING OIL

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In Morocco, oil consumption expected annual growth averaging 2.6% in 2012- 2025 interval. In 2011, the Kingdom advanced with an important initiative for the oilseeds sector development for the period 2013–2020. The program target is to reach 127 000 hectares of cultivated oilseed crop surface in Morocco. Moreover, the new program aims to produce 93 000 tons of oilseed in 2020, compared with fewer than 10 000 tons in 2011 [1].

Improvement of this sector will be accompanied by the development of refining industry and generation of wastes as acidic oil, activated earth, biomass, etc... Valorization of the wastes is a challenge. It is known that the main way to valorize this material is the biodiesel production. The biodiesel is a mixture of fatty acid methyl esters (FAMES). At the same time as it has already proved its efficiency in urban transportation, its usage will continue increasing because of its ready availability, renewability, lower sulfur and aromatic content, and biodegradability. The biodiesel prepared by transesterification of vegetable oils in presence of methanol. But methanol is not a renewable resource than ethanol. So this work is devoted to preparation of biodiesel by ethanolysis. The feedstock is similar to the acidic oils. The process is called "three steps biodiesel production (TSB)". The first consists of three phases: i) homogenous acid catalyzed esterification, ii) neutralization and iii) heterogeneous catalyzed transesterification. The obtained biodiesel was analyzed by using NMR, FT-IR and chromatography GC-MS. The results confirm that the TSB biodiesel did not contain any trace of glycerol, and it did meet the international standards.

KEYWORDS: ethanolysis; biodiesel; morocco oil seeds.

[1]David Jackson,YaminaCherrou, Nuno Santos, Morocco Oil seeds sector reviewFOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 2014,

OPTIMAL WATER ACTIVITY OF CONSERVATION AND MODELLING OF SORPTION ISOTHERMS OF *MARRUBIUM VULGARE* LEAVES**Abdelkader Lamharrar^{*}, Ali Idlimam, Abdessamade Leknizi, Mohamed Kouhila**

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The medicinal and aromatic plants have a great importance for both the pharmaceutical industry and the traditional. The genus *Marrubium* comprises ten species, which are found wild in many regions of Morocco. Among them, *Marrubium vulgare*, is a perennial herb of the Labiates family which is commonly known "Marriout" in Morocco. It possesses tonic, aromatic, stimulant, expectorant, diaphoretic and diuretic properties. It is helpful for bronchial asthma and non-productive cough. It was formerly much esteemed in various uterine, visceral and hepatic affections and in phthisis. In the Mediterranean region, *M. vulgare* is frequently used in folk medicine to cure a variety of diseases. The plant is reported to possess hypoglycemic, vasorelaxant, antihypertensive, analgesic, anti-inflammatory, antioxidant activity, antiedematogenic activity, and many other biological activities. In traditional Moroccan medicine it was used as anti sinusitis treatment.

The plant *Marrubium vulgare* used in our study was collected at Ourika Valley, Marrakesh Morocco. The stability of a dehydrated medicinal plant is influenced by its water activity. This stability is mainly a consequence of the relationship between the equilibrium moisture content and its corresponding water activity. Knowledge of the sorption properties of foods is of great importance in medicinal plant to know and understand many problems such as the design and optimization of processes such as drying, especially in the quantitative approach to the prediction of the shelf life of dried medicinal plant. Equations for modeling water sorption isotherms are of special interest for many aspects of medicinal plant preservation by dehydration. Consequently knowledge of water sorption isotherms of *Marrubium vulgare* leaves is necessary.

The hygroscopic equilibrium could be achieved by a dynamic or static method. In the present work, a static method is used. The method is based on the use of saturated salt solutions to maintain a fixed relative humidity R_h . The mass transfers between the product and the ambient air are assured by natural diffusion of the water vapour. The atmosphere surrounding the product has a fixed relative humidity for every working temperature imposed on the system.

Six salts were chosen {KOH, (MgCl₂, 6H₂O), K₂CO₃, NaNO₃, KCl and (BaCl₂, 2H₂O)} so as to have a range of water activity of 0.0572-0.0898. The experimental apparatus consisted of six glass jars of 1 litre each with an insulated lid. Every glass jar was filled to quarter depth with a saturated salt solution. Duplicated samples each of 0.2 g (± 0.0001 g) for desorption and 0.1 g (± 0.0001 g) for adsorption were weighed and placed into the glass jars. The weight recording period was about 3 days. This procedure continued until the weight was constant. The equilibrium moisture content of each sample was determined in a drying oven at 105 °C for 24 h. The hygroscopic equilibrium of *Marrubium vulgare* leaves was reached in nine days for desorption and eighth days for adsorption.

The value of the optimal water activity for conservation of *Marrubium vulgare* leaves is $a_{wop} = 0.35$.

The GAB and LESPAM models were found to be the most suitable for describing the sorption curves.

KEYWORDS: Water activity; Sorption isotherms; Modelling; *Marrubium vulgare*

A NEW APPROACH TO INVESTIGATE CO₂ STORAGE: EXPERIMENTAL STUDY OF THE INTERACTION BETWEEN CO₂ – WATER –ROCK

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World energy consumption is greatly increasing in recent years. In this context, fossil fuels such as oil, gas and coal will continue to play an important and dominant role. This growth led to an increase in greenhouse gas emissions, which are largely responsible for global warming. Faced to this situation, several solutions are planned to obtain a significant reduction in CO₂ emissions, control of energy consumption, the development of energies with better carbon footprint and the enhancement of techniques used for the capture as well as the underground storage of CO₂.

Geological sequestration of CO₂ is the most promising strategy in terms of capacity to reduce emissions of greenhouse gases. Carbon dioxide will be sequestered for geological periods of time, and then it depends on the performance of the cap rock to prevent the CO₂. The interactions between CO₂ and rock are widely unexplored. a view to characterize potential CO₂–water– rock interactions, through a laboratory experiment, various samples have been experimentally reacted in low-salinity water with supercritical CO₂ in situ reservoir conditions (P = 90 bar and T = 60 °C) for 15 days.

The characterization, obtained prior to and following reaction, and the changes in the mineralogy of selected various samples were investigated by X-ray diffraction, BET, SEM and TGA method.

Also, CO₂ adsorption capacities of different materials (i.e. clay evaporate and sandstone) are measured and the physical as well as chemical mechanisms of CO₂ retention were determined

KEYWORDS: CO₂ storage; adsorption; BET; MEB.

STUDYING THE CONTRIBUTION OF THERMOELECTRIC DEVICES TEG TO THE MITIGATION OF CLIMATE CHANGE

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The impacts of climate change and the environmental damage, due to strongly elevated greenhouse gas emissions by burning fossil fuels, while energy demands continue to increase with economic development and a growing world population, all of that's calls for a greater focus on adaptation more efforts in order to maintain future energy security. For this purpose, intensive research has been done to find and prove new energy sources like renewable energy others than the conventional energy sources. And to conceive and promote new electrical energy production systems like the solar panels, which are environmentally friendly.

Like the photovoltaic panel, the systems that we studying her can also produce electrical power from a renewable energy source like solar energy with 0 emission of greenhouse gas. In fact, this system namely thermoelectric generator TEG has become more important in recent years because of the societal needs for energy sustainability on our planet and it flexibility in designing of new innovative systems based on it.

This study provides comprehensive theoretical results of suitable options that thermoelectric generator can offer for mitigating climate change through limiting or preventing greenhouse gas emissions to reduce their concentrations in the atmosphere and their environmental impacts and socioeconomic effects and climate protection. It also gives an adaptation and an examination of it potential in making a greater contribution in the energy future.

Many case scenarios are presented in this paper for electricity production and direct use of harvesting energy by the thermoelectric generator. Significant results provide it potential to generate an important electrical energy compared with a photovoltaic panel under defined conditions. This is a study examining an installation in the renewable energy field of a system that generates electricity from heat using the thermoelectric effect based in directly converting heat into electricity. In this work an improved model based on one dimensional steady analysis of the thermoelectric generator is shown and it was used during simulation of energy harvesting processes and it was studied under different operating conditions.

The study will first examines the electrical power production by the thermoelectric generator, by modeling and simulating the thermal and the electrical parameters in order to estimate the optimal production of electrical energy and to study the wide range of applications that offers such as energy harvesting from industrial, domestic, transportation... and especially solar energy conversion.

In a second step, the study will compare the greenhouse gas emissions and production costs of fossil fuels and a review on scope of CO₂ mitigation through a thermoelectric generator.

In a third step, it will present the socio-economic effects and the environmental impacts of utilizing a thermoelectric generator.

Unlike a photovoltaic system, this study proves that the thermoelectric generators can work even in the absence of the light As long as they are a temperature difference between the surfaces of the thermoelectric generator.

The results also show that this system can be implemented in buildings in order to save the consumption of electric power and allow the injection of this energy into the power grid.

KEYWORDS: Renewable energy; Thermoelectric; Electrical energy; climate change; Energy harvesting.

NUMERICAL INVESTIGATION OF PCM SOLIDIFICATION IN A FINNED RECTANGULAR HEAT EXCHANGER

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Because of the rise of energy costs, thermal storage systems designed for the heating and cooling of buildings are becoming increasingly important. Energy storage cannot only reduce the time or rate mismatch between energy supply and demand, but also plays an important role in energy conservation. One of the most preferable storage techniques is the Latent Heat Thermal Energy Storage (LHTES) by PCMs due to its important energy storage density and high isothermal storage process.

The present paper presents a numerical study of the solidification of PCM (paraffin RT27) in a rectangular thermal storage for air conditioning systems taking into account the presence of natural convection (**Fig. 1**). The first part includes the presentation of a numerical model based on the continuity, momentum, and thermal energy equations, treated by a finite volume method. The main objective of this numerical approach is the study of the effect of natural convection on the PCM solidification time and the impact of fins number on heat transfer enhancement. It also aims at investigating the temporal evolution of PCM solidification, and solidification front, as well as the longitudinal profiles of the HTF in duct.

The present research work undertakes the study of two cases, the first of which treats the solidification of PCM in a PCM-air heat exchanger without fins, while the second focuses on the solidification of PCM in a heat exchanger of the same type and the same geometry and under the same conditions but with the addition of fins (3 fins, 5 fins and 9 fins).

In the presence of fins, energy extraction from PCM to airflow occurs at faster rate, which contributes to the reduction of the discharging time and the increase of the outlet air temperature. However, for a great number of fins (9 fins), the enhancement of the solidification process is not significant because of the effect of confinement of PCM liquid spaces on the development of thermo-convective flow.

It appears that the hypothesis according to which the thermal convection can be neglected is not justified. Indeed, considering the natural convection phenomenon. The outlet air temperature is higher by about 7% when taking into account the natural convection. On the other hand, it can be concluded that the effect of natural convection is not very significant for this geometric configuration this can be explained by the stratification of the PCM from colder to hottest in the bottom of the PCM module during heat transfer which prevents the formation of thermo-convective cells in these areas and then makes transferring almost conductive.

During the first 30 minutes, the increasing temperature of the HTF exceeds 8°C. When solidification progresses from the surfaces of the PCM-container and propagates to the central liquid phase, an insulating layer will be created at the vicinity of the container surfaces and the fins, causing a lower heat exchange rate between PCM and air. As the solid PCM layer gets thicker, a progressive regression of the field of movements is induced in the liquid phase, thus leading to the inhibition of heat extraction process. After about 2 hours, 68% of the PCM became solid (**Fig. 2**), and heat transfer was almost dominated by conduction mechanism.

Keywords: numerical simulation, solidification, PCM, thermal energy, natural convection, fins.

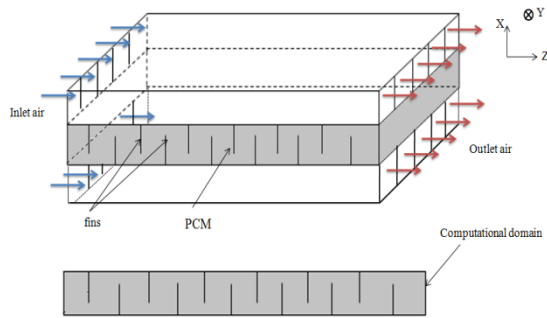


Fig. 1. Studied configurations and computational domain

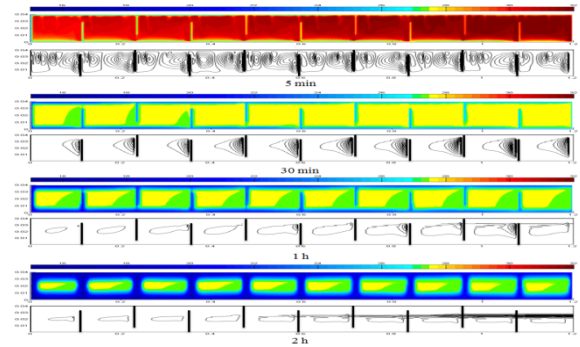


Fig.2. Temporal evolution of the temperature fields and corresponding stream lines (9 fins)

A NUMERICAL STUDY OF HYDROGEN,EFFECTS ON HOMOGENEOUS CHARGE COMPRESSION IGNITION ENGINE FED BY DIESEL/BIODIESEL BLENDS

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Due to the scarcity of fossil fuels on our planet, scientists are looking for other energy resources. Among the alternative fuels, ester biodiesel has proven increasingly promising. Park et al. [1] have characterized the application of *DME* in internal combustion engines (*ICE*), including fuel properties, spray and atomization characteristics, combustion performance and exhaust emission characteristics. They also discussed the technological problems associated with its application in actual engine systems and described the field test results of developed *DME*-fueled vehicles. Hedfi et al. [2] have characterized and controlled, in real time, the impact of bioethanol on spark ignition engine performances and NO_x emissions. It has been found that carbon monoxide (CO) emissions are lower near the stoichiometry. In addition, a small NO_x emissions rates have been obtained for lower rich mixture values. Shahir et al. [3] have characterized the partial substitution of diesel with ethanol/bioethanol rather than completely replacing it. They found that diesel blends and ethanol/bioethanol can be used in the existing *ICE* without any major modifications. No [4] has improved the use of inedible vegetable oil fuels for the diesel engine.

The main objectives of the current study are the identification of biodiesel effects, purely used or in mixture with diesel, and different types of addition (hydrogen, DME and ethanol) on ITE, engine work, cylinder pressure and gas temperature of a HCCIE. Based on a thermodynamic and kinetic analysis, we aim to characterize the combustion reaction parameters such as the time-variations of pressure and temperature. The rich mixture was varied in order to obtain the optimum operating conditions for the engine. In addition, a kinetic analysis is performed to characterize the progress of the combustion reaction and final composition of exhaust gas such as CO/CO₂ ratio. This simplified model, which has been validated by the most available published results, is used to control the addition effect of hydrogen, DME or ethanol to diesel/biodiesel blends on the engine performances and CO emissions. An optimization of the ITE as a function of fuel mass consumption allows to check the engine proper functioning as well as its safety.

Numerical calculations were performed to investigate the effects of hydrogen, dimethyl-ether (DME) or ethanol addition on a homogenous charge compression ignition engine (HCCIE) fed by diesel, biodiesel or different diesel/biodiesel blends. The indicated thermal efficiency (ITE), engine work and fuel mass consumption are calculated for different rich mixture values. An optimization of ITE and fuel mass consumption is computed in order to have the same combustion parameters of usual diesel (i.e. cylinder pressure and gas temperature) and the proper operating of the engine. The main results indicated that DME has the highest ITE gaps (i.e. 0.329-0.485%) compared with those of hydrogen (i.e. 0.06-0.09%) and ethanol (i.e. 0.3-0.443%). However, 20% addition of hydrogen, DME and ethanol to diesel/biodiesel blends leads to a decrease in engine performance such as cylinder pressure, gas temperature and ITE. In order to generate a sufficient work, it is found that this decrease can be

avoided with an increase in fuel consumption around 39.78-44.6%. In addition, ITE has been decreased less than 4.492% for the case of pure biodiesel compared with that of pure diesel. Moreover, biodiesel has the higher CO emissions values compared with those of pure diesel. Furthermore, CO emissions have been reduced for all additives cases.

KEYWORDS: compression ignition engine; indicated thermal efficiency; biodiesel; hydrogen; DME; ethanol

REFERANCES

- [1] S. H. Park and C. S. Lee, "Applicability of dimethyl ether (DME) in a compression ignition engine as an alternative fuel," *Energy Conversion and Management*, no. 86, p. 848–863, 2014.
- [2] H. Hedfi, H. Jedli, A. Jbara and K. Slimi, "Modeling of a bioethanol combustion engine under different operating conditions," *Energy Conversation and Management*, no. 88, p. 808–820, 2014.
- [3] S. Shahir, H. Masjuki, M. Kalam, A. Imran, I. R. Fattah and A. Sanjid, "Feasibility of diesel–biodiesel–ethanol/bioethanol blend as existing CI engine fuel: An assessment of properties, material compatibility, safety and combustion," *Renewable and Sustainable Energy Reviews*, no. 32, p. 379–395, 2014.
- [4] S.-Y. No, "Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: A review," *Renewable and Sustainable Energy Reviews*, no. 15, p. 131–149, 2011.

EFFECT OF SOLAR DISTILLATION BY SCHEFFLER REFLECTOR ON ESSENTIAL OIL COMPOSITION OF *THYMUS SATUREIODES*

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Medicinal and aromatic plants “PAM” acquire great importance in the international market and occupy an alternative culinary and therapeutic importance. These are in general used as raw materials for the extraction of active substances or chemical precursors and mainly for the production of teas, homemade-remedies, fluid extracts and also powders of dried plants. The various applications of essential oils make it with enormous importance in industrial scale and trade. Hence, *Thymus satureioides* plant was chosen for its effects among them antiseptic, antispasmodic, tonic, antibacterial and anti-inflammatory. Specially, the essential oil has been used in flavouring industries, food preservation and aromatherapy purposes.

Essential oils are generally obtained in laboratory by various extraction techniques such as steam distillation, solvent extraction, water distillation, vacuum microwave distillation, maceration and expression or cold pressing. Hence, renewable energy exploitation plays a crucial role in reducing the industrialization cost and the environmental problems due to the use fossil fuels. Solar energy can be used to improve energy security and economic growth in industry. Promoting innovative solar concentrator can open new opportunity to small companies and rural development for the extraction of essential oils from aromatic plants.

The purpose of our study is to evaluate the distillation of *Thymus satureioides* essential oil and to valorize the distillation process using renewable energy by the use of Scheffler reflector.

Fresh aerial parts of *Thymus satureioides* in the full flowering stage were used. The Scheffler Reflector uses the same principle of traditional still “the steam distillation”. The distillation unit consists basically of four parts: furnace (heat source based on solar energy), distillation still, condenser, and oil separator.

The influences of this distillation process on phenolic compounds were investigated in comparison with other usual distillation methods. The quality and quantity of phenolic content of the essential oil obtained by scheffler reflector was identified. The phenolic content was identified by the Folin–Ciocalteu method. However, the phenolic compound of essential oil was characterized by gas chromatography coupled to mass spectroscopy (GC-MS) type GC-MS Trace (GC Ultra - ITQ900, ThermoScientific, USA).

The compounds identification was performed by comparing their mass spectra with data bank and homemade library mass spectra built up from pure substances and components of known essential oils and MS literature data, and by co-injection with an authentic sample. Also the constituents of essential oils were identified based on their Kovats Index, calculated in

relation to the retention time of a series of alkanes (C4–C28) as reference products. The efficiency and benefit of this process have been demonstrated.

KEYWORDS: Essential oil; phenolic compounds; distillation; scheffler.

Acknowledgement

The authors gratefully acknowledge the Ministry of Higher Education, Scientific Research and Professional Training of Morocco, Priority Research program (PPR-B-Mahrouz-FS-UCA-Marrakesh) for financial support and professors of CNEREE for allowing as the use of the scheffler reflector and their technical help.

USING A MICROBIAL FUEL CELL AS AN ALTERNATIVE ENERGY SOURCE

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The current study explores the ability of a microbial fuel cell to generate electricity, while carrying out a biological treatment of wastewater. Supplying raw sewage water in batch mode at anaerobic conditions, within timeframes that are linked to COD and the biocatalyst potential of the bacteria used, provides voltage that is minimal compared to the conventional battery, but much more durable than it.

Kinetics study will be done to better understand the limitations of mass transport diffusion without adding easily degradable organic substrates. A kinetics study of the cathode will also be conducted with Platinum (Pt) at variable loads. This research aims to demonstrate which of the anodic or cathodic kinetics, are limiting the overall performance of the fuel cell.

In addition, the study discusses the economic factors favoring the utility of using microbial fuel cell on a small scale (domestic).

KEYWORDS: Microbial fuel cell; Electrochemistry; Wastewater treatment; Biofilms; Biocatalysts.

THE OPERATING PARAMETERS OF BRACKISH WATER: DESALINATION SYSTEM USING SOLAR ENERGY

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Morocco, which has brackish water resources and significant solar potential, must use desalination; it is the solution to the water shortage problem for remote and decentralized regions, using a solar desalination system humidification dehumidification, because the technique of desalination by humidification dehumidification is regarded as a promising technique.

The method of desalination by humidification dehumidification is a method of desalination thermal, in our case it acts of thermal solar energy with a cylindro-parabolic solar concentrator, this energy is used to heat the temperature of brackish water pulverized in the humidifier, in order to increase the temperature and the moisture of the air circulated in the system, for an electric autonomy of the system we added photovoltaic system.

Our research is focused on the study of a solar desalination system with humidification dehumidification, to assess the various operating parameters of our system. To demonstrate the potential of solar-driven humidification-dehumidification desalination.

KEYWORDS: Desalination, Humidification, dehumidification, solar energy.

STUDY OF PHYSICO-CHEMICAL QUALITY OF BRACKISH WATER REVERSE OSMOSIS DESALINATION PLANT IN BENGUERIR, MOROCCO.

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Water and environment appear as two major problems closely related to the evolution of humanity. The water is very unequally distributed, more than a third of the land on the planet are subject to arid expanses of water shortages throughout the year or seasonally. To cope with the shortage of water, desalination of brackish water is a common technique to mitigate this growing shortage of fresh water. However, desalination processes require large quantities of energy, so their implementation is jeopardized by a significant environmental impact if fossil fuels are used. In addition, the cost of the different desalination techniques is very closely linked to the costs of energy. Therefore, in a context of continuously rising energy costs and with the impending exhaustion of the conventional energy resources, the development of desalination technologies associated with the use of renewable energies is a very attractive and promising prospect.

In this work we presented a reverse osmosis plant powered by photovoltaic solar energy. This reverse osmosis plant is used for the desalination of brackish water of Benguerir – Morocco. We studied also the quality of this brackish water, for each reverse osmosis step. To characterize this brackish water we performed physico-chemical analysis and bring out the parameters that determine the water quality to know: The conductivity; temperature; pH; cations (calcium, magnesium, potassium...); anions (chloride, sulfate, nitrate...); trace elements (manganese, aluminum, phosphorus...).

KEYWORDS: Reverse osmosis; Brackish water; Physico-chemical analysis; Photovoltaic.

Acknowledgement

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AIR STREAM HUMIDIFICATION ENHANCEMENT BY EVAPORATING SEAWATER

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The evaporation of liquid film has been extensively studied in the past. This phenomenon has become the main process for multiple thermal applications, especially desalination systems based on air humidification and dehumidification. In fact, solar desalination technologies are being considered and many solar devices have been developed on the basis of liquid films evaporation. In this numerical study, we investigate the effect of liquid film inlet conditions, including salinity, on the air stream humidification in a vertical tube.

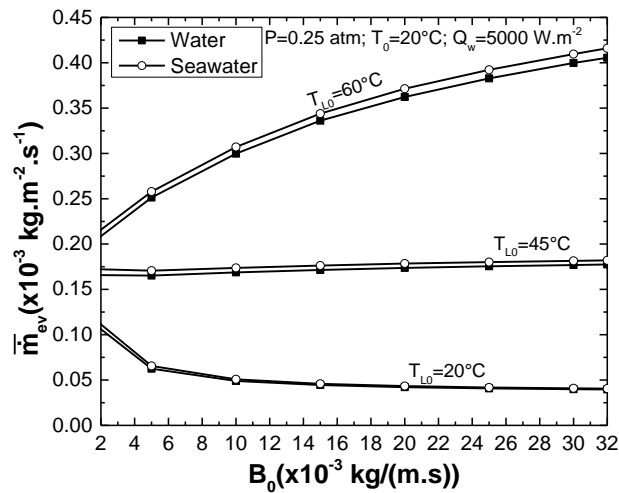


Fig. 1 Effect of inlet mass flow B_0 and inlet temperature of liquid film T_{L0} on the total evaporating rate \bar{m}_{ev} .

In this study, simulations have been done considering pure water and seawater liquid films. A fully implicit scheme is employed. The numerical solution is realized using finite difference method. Each finite-difference equation's system forms a tridiagonal matrix solved using the Tridiagonal matrix algorithm (TDMA). The equations are solved for both gas and liquid phases.

To evaluate heat transfer characteristics in this process, latent and sensible heat flux are analyzed. A remarkable increase in latent and sensible heat flux at the interface between liquid film and air stream is found by the use of seawater, resulting in an increase of evaporating rate comparing to pure water. Attention is also turned to the effect of inlet liquid parameters on the total evaporating rate \bar{m}_{ev} . The figure 1 shows the variation of \bar{m}_{ev} with inlet mass flow B_0 and considering various inlet liquid temperatures T_{L0} . It is observed that the behaviors of \bar{m}_{ev} depend strongly on the liquid temperature T_{L0} . For $T_{L0}=20^\circ\text{C}$, the total evaporating rate decreases with the increase of B_0 and the difference between seawater and fresh water is insignificant. An opposite compartment is observed with the highest value of T_{L0} : the total evaporating rate increases with B_0 , and it's more important for seawater case. Therefore, with

$T_{L0}=45^{\circ}\text{C}$ the total evaporating rate remains constant but is higher for seawater. It's important to note that when \bar{m}_{ev} takes high values, this reflects that the humidification of air streams increases in turn.

In the released study, the following conclusions are demonstrated:

- The latent and sensible heat flux are increased by the use of seawater.
- Air stream humidification is higher in the case of seawater.
- The humidification of the air stream when increasing the inlet mass flow rate depends on T_{L0} : for inlet liquid film temperature less than 45°C it decreases, otherwise humidification increases.

KEYWORDS: desalination; seawater; film evaporation; mass transfer; salinity

STEAM CONDENSATION IN DESALINATION UNIT

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The growth in demand for freshwater caused by various human activities has increased efforts to design and achieve effective desalination units whose operating principle is based on the phenomenon on evaporation and condensation with presence of a liquid film. The distillation method is based on the phase change such as multiple effect distillation (MED) and multi-stage flash (MSF) methods. Heat and mass transfer during condensation of vapour have been the subjects of many engineering and industrial applications such as desalination, refrigeration and chemical processing, etc.

For this reasons, a numerical analysis is performed for condensing steam inside a vertical tube with constant wall temperature. An implicit finite difference method is employed to solve the coupled governing equations together including the boundary and interfacial matching conditions.

The problem under consideration is a vertical tube with length L , and radius R . Water vapour enters the tube with a uniform (velocity u_0 , pressure P_0 , temperature T_0 and relative humidity ϕ_0); the wall temperature is maintained at T_W . The thickness δx of liquid film is varied according to the amount of vapour condensed along the tube.

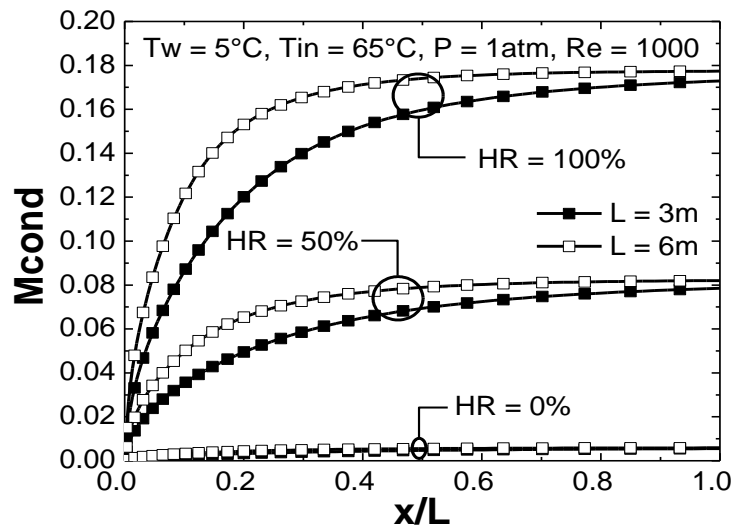


Fig. 1 Effect of inlet relative humidity on the accumulated condensate rate M_{cond} along the tube.

A numerical solution has been carried out to investigate condensation of water vapour in vertical tube. The effects of inlet relative humidity, inlet temperature and tube length on the condensation process have been analysed. It was found that the accumulated condensate rate is enhanced by increasing inlet temperature or inlet relative humidity.

Fig. 1 presents the effect of the relative humidity on the accumulated condensate rate along the tube. For a given value of the tube length L , the accumulated condensate rate M_{cond} decreases as the relative humidity decreases because with a small ϕ_0 , the presence of non-condensable gas at the interface reduces the liquid film thickness. When ($\phi_0 = 0$), the

condensation rate becomes null because there is no exchange of heat or mass transfer with the absence of vapour. It is also observed that M_{cond} increases with increasing the tube length.

The main conclusions from this study are summarized.

- The accumulated condensate rate and liquid film thickness are enhanced by increasing inlet temperature or inlet relative humidity.
- The presence of non-condensable gas cause reduction of performance and efficiency.
- Increasing the tube length produce high amount of vapour condensed along the tube.

KEYWORDS: Condensation; Desalination; Liquid film; Thermal process; Vertical tube

NUMERICAL STUDY OF HEAT AND MASS TRANSFER IN THE EVAPORATION OF BINARY LIQUID FILM

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INTRODUCTION

This paper deals with a numerical analysis of comparison of two configurations to improve heat and mass transfer by the evaporation of two-component liquid film in a vertical channel under mixed convection. The liquid mixture falling down on right plate of channel consists of water and ethanol. Two configurations are considered in this study, the first one consist in applying a uniform heat flux density to the right wall while in the second case, the same quantity of heat, was used for preheating the liquid mixture at inlet.

The model solves the coupled governing equations in both phases together with the boundary and interfacial conditions. The systems of equations obtained by using an implicit finite difference method are solved by Tridiagonal Matrix Algorithm method. The influence of the inlet film composition, inlet velocity of dry air and inlet liquid film temperature of heat and mass transfers are examined

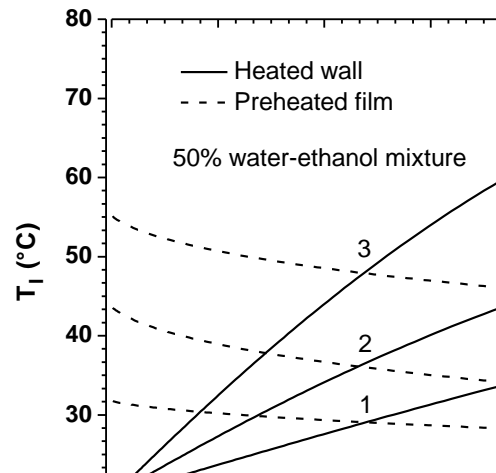


Fig 1: Distributions of interfacial temperature along the channel for: 1- $Q_f = 2000 \text{ Wm}^{-1}$, $B_0 = 4. \cdot 10^{-2} \text{ kgm}^{-1} \text{ s}^{-1}$, 2- $B_0 = 2. \cdot 10^{-2} \text{ kgm}^{-1} \text{ s}^{-1}$, 3- $Q_f = 5000 \text{ Wm}^{-1}$.

The effect of inlet liquid mass flow rate and heat flux density on the interfacial temperatures is shown in figure 1. In the first configuration the interfacial temperature T_i increases monotonically as the flow goes downstream. This feature is due to the fact that the binary liquid film absorbs sensible heat from the gas stream as the liquid film falls along the channel. In contrary, in second configuration the interfacial temperature T_i decreases monotonically in the flow direction due to the evaporative cooling. This indicates that energy needed to sustain the evaporation must come from the internal energy of the liquid film. This is a consequence of a reduction in liquid film temperature.

CONCLUSION

Based on the numerical results obtained, the following conclusion can be drawn:

- The first configuration with applying a heat flux density to the wall channel is the best technique to obtain a significant evaporated average mass flux density.
- The heat and mass transfer strongly depends on the inlet liquid concentration of water.

KEYWORDS: evaporation; binary liquid; water-ethanol; Heat and mass transfer.

EXPERIMENTAL AND NUMERICAL STUDY OF AN AUTONOMOUS MEMBRANE DISTILLATION UNIT IN MARRAKECH AND SFAX

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Water desalination faces major environmental challenges arising from the discharge of brine and energy consumption. Major conventional desalination processes (distillation and reverse osmosis) consume a large amount of energy derived from fossil resources, which is responsible for harmful CO₂ emissions. During recent years, membrane distillation (MD) has emerged as a promising renewable energy-powered technique for producing freshwater. Indeed, this technique has many advantages such as the use of low temperature solar energy and has low environmental impact with low brine rejection. Moreover, MD compared to conventional thermal desalination is less demanding regarding vapor space and building material's quality leading to potential lower construction costs. Membrane distillation is a thermal process wherein the water vapor is transported through a hydrophobic porous membrane. The hydrophobicity of the membrane prevents the entry of water liquid into the pores by surface tension.

The aim of this study is to develop an experimental and numerical study of autonomous MD units coupled with low temperature solar collectors and PV modules. An experimentally validated model is developed. It is based on heat and mass transfer balances that describe the heat and mass transfer mechanisms taking place inside the membrane. The behavior of each component of the units as well as the entire system is investigated in connection with the system parameters and meteorological conditions. Two MD configurations are considered, namely *Direct Contact Membrane Distillation* (DCMD) and *Permeate Gap Membrane Distillation* (PGMD). Particular attention is paid to the membrane module in each of these configurations. An experimental study is conducted in real conditions of Sfax (Tunisia) and Marrakech (Morocco). This study is performed with two semi-industrial pilot units based on the two considered membrane configurations. The two units are monitored during long periods.

KEYWORDS: Desalination - Distillation - Energy - Production - salt water -Energy Renewable - Solar energy - Thermal - Efficiency energetic.

MODELING OF THE DRYING KINETICS OF MYRTUS COMMUNIS L.**M. LEKRATI¹, L. ZEROUK¹, A. IBNLFASSI², E. SAAD¹**¹ Laboratory of Physical-Chemistry of Processes and Materials (PCPM), University Hassan 1^{er}, FSTS, B.P:577, Settat, Morocco.² Laboratory of Environment and Development Sciences, University Hassan 1^{er}, FSTS, B.P:577, Settat, Morocco.**Introduction**

The water content of aromatic and medicinal plants (WFP) constitutes the first factor influencing their conservation during storage. From where the drying operation is very efficient to conserve these agricultural products with great interest. It was in that vein that study which aim is establishing a simple and reliable model in order to characterize the drying speed of the myrtle, plant known by its multiple applications in pharmaceutical, cosmetics and agri-food industries. The improvement of the drying effectiveness requires the control of the heat transfers that governs the product behavior during drying. The aim of this study is to model the drying kinetic based on the similarity between chemical kinetic and drying kinetic. The drying speed of myrtle by fluidization is determined under various operative conditions. The considered parameters are the drying air temperature, the product absolute humidity and the drying air speed. The analysis of these parameters influence on drying speed and the determination of the model constants are based on experimental results obtained.

Main results

According to the experience, it is deduced that drying speed increases as the speed and the temperature of the drying air increase. Also, a model representing the relation between the myrtle drying speed and the principal parameters of drying such as the drying air temperature, the product absolute humidity and the drying air speed was established. The formula obtained is the following: $|dN_s/dt| = \exp(-a/T_p + c.V_a - b + d + \ln\alpha).(N_s - N_{se})$ with : $a = 5771,4$; $b = -13,665$; $c = 0,7853$; $d = -4,4343$; $\alpha = 0.0502 \text{ min}^{-1}$.

Conclusion

The obtained results show that the myrtle is a hygroscopic product and the water transfer is made by capillarity.

KEYWORDS: Model; drying speed; fluidization; drying kinetic; Myrtus communis L.**References**

- [1] Catherine BONAZZI et Jean-Jacques BIMBENET, Séchage des produits alimentaires, principes (Les techniques de l'Ingénieur), F 3000, 2003, p. 1
- [2] Coda L., Illiquore di mirto: aspetti storici e tradizione. In Franco M.A., Versini G., Saba R., Caratterizzazione del liquore Mirto di Sardegna tradizionale. Cagliari : Litotipografia Valdes, 1998, p. 11-34
- [3] L.F.G. Andria zafimahazo, Determination of the drying speed in thin layer of shrimp, Revue des Energies Renouvelables, vol. 13 N°2 (2010) 295 – 309
- [4] André CHARREAU et Roland CAVAILLÉ, Séchage, théories et calculs (Les techniques de l'Ingénieur), J 2480, 1995, p. 8

- [5] J.L. Bailleul, D. Delaunay et Y. Jarny, 'Identification des Propriétés Thermiques de Composites Fibres de Verre/ Résine Thermodurcissables. Application à l'Optimisation de Procédés de Moulage', Revue Générale de Thermique, vol. 35, pp. 65 - 77, 1996
- [6] Thierry Foucart, 'Colinéarité et régression linéaire', Mathématiques et sciences humaines, vol. 1, N° 173, 2006, p. 5-25
- [7] M. Kouhila, Etude Expérimentale du Séchage Convectif de la SAUGE dans un Séchoir Solaire muni d'un Appoint Electrique. Revue des Energies Renouvelables, Chemss (2000) 33-38
- [8] Sarra MTIRI, analyse cinétique du séchage convectif du romarin sous des conditions constantes et variables. VIème Congrès International sur les Energies Renouvelables et l'Environnement, 2012.
- [9] A. Benhamou, 'Diffusivité hydrique et cinétique de séchage solaire en convection forcée des feuilles de marjolaine'. Revue des Energies Renouvelables, vol. 11 N°1, 2008, 75 – 85

THERMAL PROPERTIES MEASUREMENTS OF CEMENT RENDER EMBEDDED WITH EXPANDED GRANULAR CLAY OR GLASS

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INTRODUCTION

In order to guarantee a better thermal performance inside buildings, decrease their high energy demand and ensure a better occupant's comfort, the Moroccan Thermal Regulation of Construction (MTRC) has become mandatory in November 2015. Indeed, its establishment requires creating favorable conditions for its implementation. For this purpose, this work aims to improve the thermophysical properties of one Moroccan building material. Accordingly, several samples were prepared mixing cement render with granular expanded clay and granular expander glass; their thermophysical properties were then investigated on two different granular size. The thermal diffusivity was determined using the flash method and the adiabatic temperature at the rear face; the thermal conductivity and the specific capacity of the samples were estimated using several numerical global minimization procedures. For this purpose a special script was written in Mathematica language. Moreover, in order to prove the validity of the realized script, both thermal conductivity and thermal capacity of the different samples were determined directly from the steady hot plat method.

MAIN RESULTS

It is shown that:

- Through the density measurement of different specimens studied that the higher the expanded granular particle (clay or glass) size is the lower is the apparent density of the sample.
- There is a well agreement between theoretical proposed models and experimental data.
- Granular expanded glass proved to be a better thermal insulator binder than granular expanded clay for all the studied samples.

CONCLUSION

This work has presented an experimental study of the new materials cement render embedded with expanded granular clay or glass. Three thermophysical properties were returned, the density was directly computed knowing the samples dimensions and dry masses, the thermal diffusivity was determined using the flash technic, and two values of the adiabatic limit temperature, thermal conductivity and the specific heat were given, first values were estimated using the global minimization and the second ones were determined through the hot plate method, it was concluded that with the increase of the particle size, the thermal diffusivity along with the thermal capacity increased, and both apparent density with thermal conductivity decreased.

KEYWORDS: Composite materials; thermal diffusivity; thermal conductivity; construction materials; thermal characterization.

THERMAL CHARACTERIZATION BY THE FLASH METHOD OF MIXTURES BASED ON WOOD DUST SPECIES USED IN MOROCCO

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Introduction

The building sector is one of the fields which knows a big energy demand in Morocco. Obviously, this energy consumption of Moroccan buildings is not only related to their use of heating and cooling but it has a wide correlation with the building materials performance as well. Then, in order to improve the thermal behavior of Moroccan buildings, the Moroccan Thermal Regulation of Construction (MTRC) has been mandatory. Consequently, the thermal optimization of building envelop has become imperative to reach the performance levels prescribed by the MTRC.

In accordance with the current context, the aim of this work is to give some alternatives that should contribute to improve thermal efficiency of some construction materials. It consists on making mixtures based on Moroccan wood dust in order to improve the thermal insulation of buildings.

Main results

The wood dust is known to have good insulation properties. Moreover, it is a by-product of wood industry which could be valuable to improve the thermal efficiency of building walls. Therefore, in this work, we have managed to mix the wood dust with other materials which are used in construction to make a comparison between the prepared mixtures and the standard ones based on plaster, lime and clay. As there are many wood species used in Morocco, the samples prepared are made from different wood dusts in order to visualize the influence of each species on the global sample performance.

The first type of samples is manufactured by mixing the wood dust with a low quantity of lime which will be used just as a binder. The objective of this preparation is to estimate the thermophysical properties of wood dust, especially volumetric thermal capacity, thermal conductivity, thermal diffusivity and thermal effusivity. The second type of samples consists on mixing plaster with wood dust in order to compare its thermal performances with the simple plaster ones. Finally, a last type of samples is made by mixing clay and wood dust. All those samples are subjected to compression test to check their compliance with the construction constraints.

To realize the study, the samples manufactured are circular and their thickness is 2cm. Their thermal characterization is operated using the flash method. Therefore, the samples have been covered with black thin painting in order to make them absorbing the thermal flow applied in this method. They have also been introduced into a stove to remove their humidity. Finally, the thermal properties will be estimated using a mathematical script transcribed on Mathematica.

Conclusion

This work has as an objective to contribute to the improvement of thermal efficiency and comfort conditions in Moroccan buildings. By the results we have obtained, this study has

allowed us to identify the impact of these mixtures on the thermal properties of walls in order to make them respectful to the new Moroccan Thermal Regulation of Construction. According to the comparison between the samples studied and the classic ones, it has been showed that these configurations are able to improve the thermal insulation of the buildings and to provide them more thermal inertia. As these conditions are satisfied, it has been concluded that these mixtures are suitable to ensure both winter and summer comfort.

Keywords: Wood dust; thermal efficiency; thermal insulation; thermal inertia, thermal characterization

EFFECT OF THE BROWNIAN MOTION OF CUO NANOPARTICLES ON THE WATER FLOW AND HEAT TRANSFER AROUND A HEATED SQUARE CYLINDER

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INTRODUCTION

The flow of pure fluid around a square cylinder has received substantial attention from researchers and extensive reviews of the pertinent studies are available in the literature [1-3.] where a wealth of information on the effects of physical parameters on the global flow coefficients and the heat transfer has been accumulated. In contrast, very few studies have been undertaken in this area using nanofluids [4-5.]. These studies showed that the global flow coefficients as well as the heat transfer rate are significantly affected by the nanoparticle volume fraction. The present research work was carried out to show the effect of the Brownian motion of the CuO nanoparticles on the water flow pattern and its related heat transfer around a heated square cylinder.

MAIN RESULTS

Computations were carried out for a CuO-water nanofluid flow around a heated square cylinder inside a plane channel under Reynolds number Re and volume fraction ϕ ranging from 60 to 160 and 0 to 5% respectively when the Prandtl number is kept constant at $Pr=6.2$. The thermophysical properties of nanofluid such as density, specific heat, thermal conductivity and viscosity are calculated based on relationships presented in the literature. The combined continuity, momentum and energy equations are solved using a finite volume method of Patankar. Fig. 1 shows the effect of the Brownian motion on the variation of the critical Reynolds number Re_{cr} , characterizing the transition from steady to periodic flow, with particle volume concentration. As it can be seen, at a fixed concentration of nanoparticles, the Brownian motion leads to an increase in Re_{cr} and this increment is more pronounced for higher nanoparticles volume fraction. One may conclude that the Brownian motion transits to unsteadiness at higher Re_{cr} than that seen without Brownian motion.

Fig. 2 depicts the variation of the global time-averaged Nusselt number over the heat transfer surface of the square cylinder with particle volume concentration for different Reynolds number with and without Brownian motion. As it can be seen, the heat transfer rate increases monotonously with increasing the nanoparticles volume fraction for all Reynolds number with and without Brownian motion. For a given concentration, results show that the heat flux undergoes reduction when considering the Brownian motion. For each value of Re and

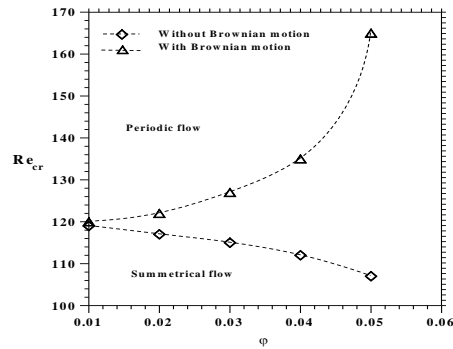


Figure 1. Variation of the critical Reynolds number vs nanoparticles volume fraction

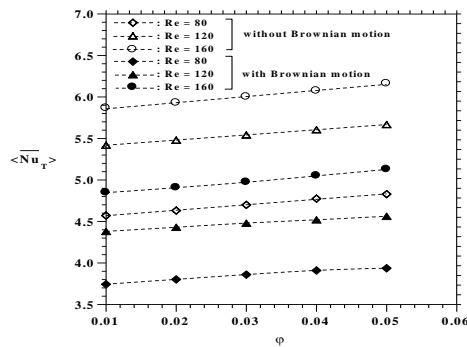


Figure 2. Variation of the global time averaged Nusselt number vs ϕ with and without Brownian motion for different Re

in the range of ϕ under consideration, numerical results show that the global time-averaged Nusselt number varies linearly with respect to ϕ .

References

- [1] Breuer M. et al., Int. J. Heat Fluid Flow, vol. 21, 2000, pp. 186–196.
- [2] Turki S. et al., Comput. Mech, vol. 33, 2003, pp. 22–29
- [3] Bouazizi L. et al., Int. J. of Mechanic Systems Engineering, vol. 3, 2013, pp. 83-88
- [4] Sarkar S. et al., Int. J. Heat Mass Transfer, vol. 59, 2013, pp. 433-450
- [5] Valipour M.S. et al., Thermal science, vol. 18, 2014, pp. 1305-1314

IMPACT OF CLIMATE CHANGE AND RENEWABLE ENERGY USE ON WATER RESOURCES IN THE SOUSS-MASSA BASIN

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The pressure on energy in general and electricity in particular has become very important. This growing demand for energy is the result of a hydro-agricultural development policy launched since the sixties by the Moroccan government, which focused on the intensive use of energy use for pumping water irrigation. This increasing energy demand is also due to urban and rural electrification (ADEREE 2014). The use of energy is essential to agriculture which is considered as the main sector of the economic development. This paper simulates the impact of Climate Change and the use of renewable energy on water resources in the region of Souss Massa using a dynamic integrated water management model (Elame and al. 2012, Elame and al. 2015). To assess the impact of pumping costs and climate change on water resources use, a simulation was conducted and was based on a comparison of water pumping costs. These costs are introduced in the dynamic model and compared to the pumping cost by solar energy.

This paper, assessing climate change combined with the use of solar energy (Scenario B), has shown the potential impact of the use of renewable energy on reducing pumping costs and thus for the use of water resources in general. Furthermore, the use of this energy source can reduce energy dependence vis-à-vis the International market and reduce also its impact on the trade balance.

The results show that the average shadow price of water remains below 3 dh / m³ the first five years knowing that it has already exceeded 5 (dh/m³) compared to scenario A, which assesses only the impact of climate change. Changing economic price for the two scenarios (A, B) follows the same trend with a difference of 2 (dh/m³) less in case of the use of solar energy (scenario B). The economic price directly influences the amount consumed for irrigation water. Indeed, there is a reduction in the use of surface water resources in the order of 17%. This amount will be offset by an increase of groundwater use because their operating cost becomes more competitive. Add to that the small decrease in the total value added or even a recorded increase in the first five years, despite the impact of climate change. This increasing of the value added is explained by the gain on pumping costs by using solar energy and the small decrease in irrigated areas.

KEYWORDS: renewable energy; agriculture, water; climate change; irrigation; economic price

References

- [1] ADEREE Agence national pour le développement des énergies renouvelables et de l'efficacité énergétique, Mars 2014. Stratégie national d'efficacité énergétique à horizon 2030 : État des lieux de la consommation d'énergie finale au Maroc
- [2] GIZ 2011. Étude du potentiel de développement de l'énergie photovoltaïque dans les régions de Meknès-Tafilalet, Oriental et Souss-Massa-Drâa. GIZ GmbH, Eschborn/Bonn, Mars et Novembre 2011
- [3] Elame F. and Doukkali R., Water Valuation in Agriculture in the Souss-Massa Basin (Morocco) . Integrated Water Resources Management in the Mediterranean Region Dialogue towards new strategy. pp 109-122. Springer Netherlands 2012

- [4] Elame F., Doukkali R. , Fadlaoui A. Modélisation économique de l'impact des changements climatiques sur les ressources en eau ; Accepté en octobre 2015 pour publication au niveau de la revue internationale NEWMEDIT (CIHEAM) DOI : 69/02-10-2015.

EFFECT OF MOISTURE CONTENT ON THE THERMAL CONDUCTIVITY OF MORTAR REINFORCED WITH DATE PALM FIBERS MESH

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The thermophysical characterization of composite vegetal fibers-mortar knows a considerable importance this last decade thanks to several advantages, such as availability, low cost or free, naturally degradable, the renewal, the abundance, non-toxic and no polluting. In addition, these vegetal fibers assure a good adhesion between fibers and solid matrix and a good thermal performance for mixing. The use of vegetal fibers as reinforcement of mortar gives a composite materials which can be used in many applications in building construction as thermal insulating and could contribute to the reduction of CO₂ emissions: less buildings energy consumption leads to less CO₂ emission.

In this work, we have chosen the date palm fibers to add it to mortar (mixing of 75% of sand and 25% of cement with a dose of water equals to 0.6) in order to determine an energy efficient composite material which will be used for building thermal insulation. The objective of our study is the investigation of effect of moisture content W_v on the thermal conductivity k of mortar reinforced with date palm fibers (DPF) mesh. In this paper, five samples (Reinforced Fiber Mortar); RFM0%, RFM21%, RFM31%, RFM48% and RFM51% have been made. The box method (device EI700) has been used for measurement of thermal conductivity. The obtained results show that the incorporation of DPF mesh, in the mortar, has a significant positive effect. It increases the insulating capacity of mortar by decreases the thermal conductivity, and also lightens sample by decrease its density. Thus, the thermal conductivity increases with volume water content. The mean ratio between the thermal conductivity of composite material in the saturation state and the one of the dry state is about two times. The evolution of thermal conductivity of composite materials as function of volume water content is compared to theoretical models.

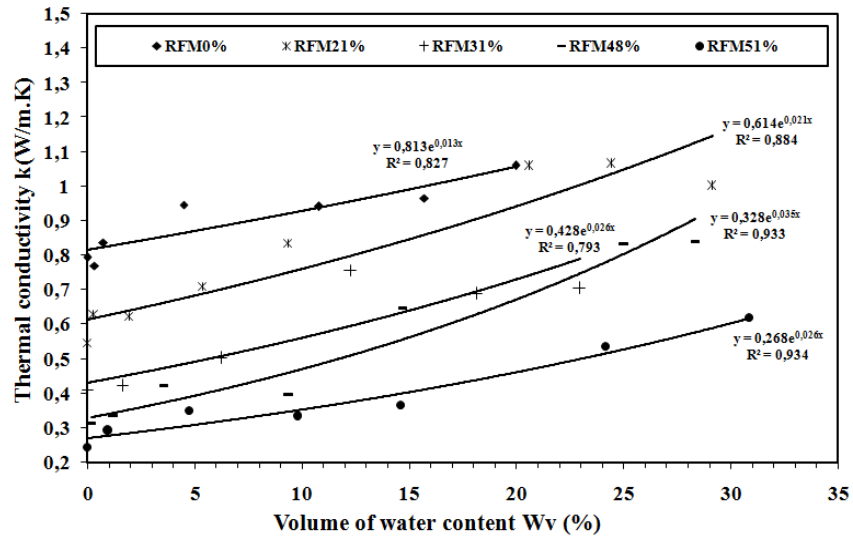


Fig. 1: Thermal conductivity of composites material with moisture content

KEYWORDS: DPF mesh; mortar; moisture content; thermal conductivity; theoretical models

ACKNOWLEDGEMENT:

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Topic 5

Society and Sustainability

ECONOMIC ANALYSIS: WHICH EFFECTIVE INSTRUMENTS IN THE FIGHT AGAINST CLIMATE CHANGE?

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Since the First International Conference on Sustainable Development, held in Rio de Janeiro in 1992, several global actions were taken with the aim of reducing emissions of greenhouse gases and to facilitate adaptation in developing countries to change climate. The consequences of this phenomenon, whose manifestations are multiple, are becoming today increasingly serious. In 2007, Nicholas Stern stipulates that the total costs of climate change are estimated 5 to 20% of global GDP in case of inaction, and only 1% otherwise. Economic science has thus mobilized to develop specific instruments in the fight against climate change.

In economics, the emissions of greenhouse gases, which are the main cause of climate change, is both a negative externality and a phenomenon of exploitation of natural resources, which are common goods. The economic policy pursued in recent years, based on different and complementary approaches. Market-based approaches are expected to be effective in terms of cost rather than trying to directly control the market players, they transform the incentives for companies and players in action voluntarily taken in the light of external costs and benefits. Economic instruments of regulation by markets are in the form of environmental taxes or permit emissions trading. In parallel, there are other economic policies that include measures to create incentives for the adoption of renewable energy sources and efficient technologies for energy consumption.

The objective of this article is to present the different economic approaches developed in recent decades, the fight against climate change, compare the main economic and financial instruments mobilized in mitigation and adaptation policies, in terms of efficiency, to finally ask their relevance in the context of developing countries.

Keywords: *Climate change, economy, instruments, efficiency*

Selected Bibliography

Daubanes J., « Changement climatique, instruments économiques, et propositions pour un accord post- Kyoto : une synthèse », Toulouse sciences économiques, 2007

Jonathan M., Harris, Roach B., Codur AM., « L'économie du changement climatique mondiale », Global Développement And Environnement Institute, Tufts University, 2014

Stern N., « The Economics of Climate Change », the Stern Review, Cambridge University Press, 2007.

CLIMATE CHANGE AND ADAPTIVE WATER MANAGEMENT STRATEGIES IN CHTOUKA AÏT BAHA REGION (SOUTHERN MOROCCO)

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There is an increasing consensus that global climate change occurs and that potential changes in climate are likely to have important regional consequences for biota and ecosystems, especially in area having vulnerable water resources as the case of ChtoukaAitBaha region (South of Morocco). The current water resources management systems have to be improved as they are still inefficient and unsustainable and water resources managers should start implementing adaptive and sustainable strategies to cope with negative impacts of climate change. Therefore, this study aims to evaluate the effect of expected changes in precipitation and temperature distributions in regional climate change projections on the availability of water resources for agriculture. Generated scenarios and models will help to better understand futures uncertainties and alternative, in order to consider how robust different decisions or options may be under a wide range of possible futures.

First, we built the historical baseline of precipitation and temperature using satellite data from different available sources such as CHIRPS, TRMM, CRU, ERAinterim. After comparison and statistical analysis CHIRPS precipitation data have been chosen because they have the highest resolution (5 km) and better correlation with observed data ($R^2 = 82\%$). Temperature data from ERAinterim were used because they have the highest resolution among other sources. Historical data (CHIRPS and ERAinterim) and future projection of both downscaled temperature and precipitation using the Coordinated Regional Climate Downscaling Experiment database (CORDEX) have been provided by ICBA MAWRED project. Projections are generated for two future periods (2030-2049 and 2080-2099) under two Representative Concentration Pathways: RCP 4.5 and RCP 8.5. Climate change models including HIRHAM, CCLM, RACMO, REMO, CNRM and WRF have been evaluated by calculating their bias. Spatial distribution maps of historical and projected temperature and precipitation are obtained using the kriging method.

The results show that temperature is likely to be increased more under RCP 8.5 which confirm most of studies conducted on climate change in other regions of the world. The most optimistic model is HIRHAM and the most pessimistic is CNRM model. Temperature will increase for most models by 3 °C in the horizon of 2030-2049 and by 4 to 5°C toward the end of the 21st century. Regarding changes in precipitation, most of models under RCP 4.5 emission scenario show a reduction of 10 to 30% in the horizon of 2030-2049 and up to 60% in the horizon of 2080-2099. Precipitations will be decreased dramatically under RCP 8.5

emission scenarios, about 80% under pessimistic model and 40% under optimistic model towards the end of the century.

This study suggests several adaptive management strategies (e.g. artificial groundwater recharge, wastewater reuse, desalination of sea water, efficient irrigation management...etc.). These strategies vary according to their action on water demand or supply and according to their implementation (feasibility, effectiveness, costs, flexibility, implementation time, uncertainty...etc.)

KEYWORDS: precipitation, temperature, model, scenario, strategies

THE ENVIRONMENTAL CONSIDERATIONS IN MAKING INDUSTRIAL LOCATION DECISION, CASE STUDY OF THE HINTERLAND OF CASABLANCA, MOROCCO

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INTRODUCTION

The main purpose of the current study is to develop a tool for supporting decision-making based on geographic information systems integrated multi-criteria decision support system use for industrial location.

The method used here is based on environmental, social and economic criteria of the industrial location. The selection of these criteria is based on the study of several models of sustainable development indicators. Then the aggregation of these criteria by the Measuring Attractiveness by Categorical Based Evaluation Technique tool allows us to evaluate the importance, to give each criterion a weight that many decision makers (public decision makers, industry professionals, public agency...) had previously consented. Finally the integration of multi-criteria model with a geographic information system enables assessment of the spatial analysis on the whole territory for the selection of industrial sites.

MAIN RESULTS

The current study had been carried out on the region of the hinterland of Casablanca, Morocco. And allows a synergetic evaluation of the suitability of the location of 12 existing industrial sites and provides also the opportunity to make the optimal choice of future industrial sites location.

The methodology we adopted includes the following steps:

- Establishment of a list of decision criteria (exclusive criteria and assessment criteria) and evaluation a tool to aid the analytic decision, namely MACBETH [13];
- Application exclusive criteria to exclude areas unsuitable for industrial location, based on legal restrictions or physical impracticability. For example, water surfaces or roads ;
- Evaluation of alternatives, from the previous step through the assessment criteria ;
- Aggregation of criteria to rank the alternatives in ascending order.
- This approach aims to plan on the entire territory of a local authority, and according to environmental, social and economic constraints, the best industrial location sites.

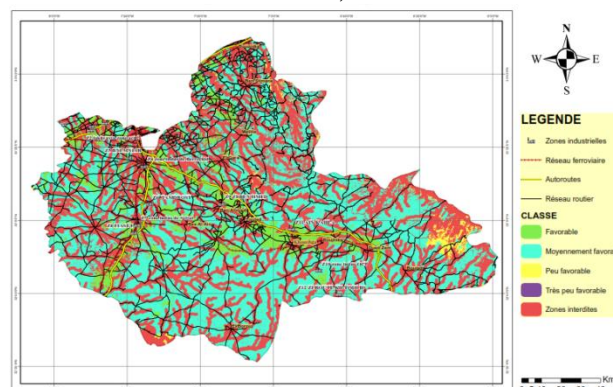


Figure 1: MAP of areas suitable industrial location Region hinterland of Casablanca Morocco (with precise positioning of existing industrial zones)

Applying our model allows to establish a model approving the appointment of both the establishment of a support tool for the analytic decision and its integration into a geographic information system for the production of maps.

The map above shows a thematic map of areas suitable industrial location in hinterland of Casablanca in Morocco. These areas are classified into 5 majors classes, so the user has an idea about the sites of implantation of possibilities respecting economic, social and environmental criteria.

In addition that viewing these results to decision makers savings mapping the development of two reflections modes : multi-criteria analysis and location as offers mapping.

The map below shows in turn the possibility of the diagnosis of the existing in terms of industrial location since it highlights the 12 major locations of the region concerned in the case study.

The spatial processing models so established enable quick assessment for the selection of industrial location sites. But to make their operation easy for a decision maker who is a priori not a specialist in geomatics, we proposed to integrate these models into a GIS application easily exploitable.

References

- [1] B. Mérenne-Schoumaker, Bulletin of the Geographical Society of Liège, 49, 31-40, 2007.
- [2] S. Oufella and al, CIIA 2009
- [3] P.Solomonan al, AppliedGeography, 36, 2013.
- [4] E.C.Banaand al .2007 International Journal of Information Technology and Decision Making, 11, 2, pp. 359-387
- [5] T. Gilberto, Zsigraiová Z, & V. Semiao, Waste Management, p 31 (2011).

SIMULATION OF FLOW IN SEWAGE NETWORKS BY THE RESOLUTION OF 1D ST VENANT SYSTEM

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INTRODUCTION

In urban areas, soil sealing provokes a considerable increase in the volume of streaming water during rainfalls and with it comes a huge solicitation of the sewer networks, This, results in overflowing and flooding when these sewer networks are under-sized, threatening the safety of people and assets and the environment where the human activity takes place.

Sewerage networks managers must make sure they have the right dimensioning for their network either in case of rehabilitation or extension. A good assessment of the transit capacity of a network requires adequate simulation models and a mastery of the calculus formulas suitable for the project area.

Generally, in Algeria, the verification of sewer networks for the purposes of rehabilitation is made through the classical method, where flow is considered uniform and permanent, assuming constant hydraulic parameters. Therefore, the average velocity, height and the water flow remain invariable. The formula used for calculating these parameters is that of Manning Strickler. However, this method is only appropriate for the dimensioning; it allows assessment of the peak flow at the outlet but not the real functioning of the network during rainfalls.

The objective of this work is to realize a simulation approach of the sewerage networks based on modelling. This implies taking account of the time parameter among other important parameters in the calculus formulas. This simulation will better understand the functioning of the networks during rainfalls, and will help make more adequate decisions to solve the problems related to sewer networks.

MAIN RESULTS

In order to assess the performance of our model under different application conditions, and verify its capacity to simulate the flowing in such situations, we have simulated the flowing in Oued Oucahaiah sewage collector on its conduits located in the east of the municipality of Kouba in Algiers.

By comparing the results from our model and those of the measurement campaign, we notice some similarity in terms of flow, velocity and height. On the one hand, this shows the consistency of the developed model, and on the other hand, the convergence of the numerical applied method.

This similarity cannot be perfect in anyway, because of iterative calculus and measurement errors. That is why a slight dissimilarity appears, especially at the beginning of the simulation, due to the choice of the initial conditions and/or boundary conditions. In fact, the hypothesis of a perfect flowing continuity at the level of the junctions generates some errors.

Moreover, the analysis of the height curve according to length shows a slight solicitation of the collector, whose second and third conduits are the most solicited. This is due to the low slopes present in the conduits and the strangulation in the last conduit.

The spatial variation curve of Froude number helps us to detect the transitions along the collector, which may cause the occurrence of hydraulic jumps. In our case, the regime remains supercritical.

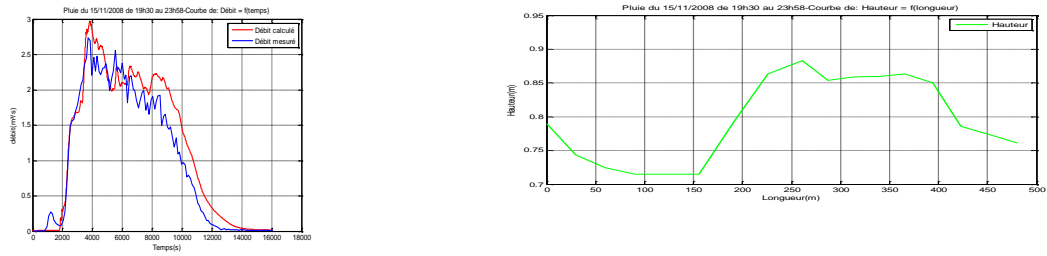


Figure 1: Simulation results

Regarding the numerical resolution of the St. Venant equations, we have seen that they can be realized by different numerical schemes. However, the resolution by explicit finite-difference approximations does not seem to be the most appropriate. In fact, the explicit schemes remain submitted to the Courant–Friedrichs–Lewy condition and consequently require using a shorter time step in order to guaranty the stability of the results. This, generates a longer calculation time and non-controllable numerical instabilities.

- [6] Carlier, M., (1986)., « Hydraulique générale et appliquée ». Edition Eyrolles 1986, 655 pages
- [7] Buyer, M., (2002). «Transport de flux en réseaux d'assainissement : modèle 1D pour l'hydraulique des collecteurs et déversoirs avec prise en compte des discontinuité». Thèse de doctorat de l'Université Louis Pasteur, Strasbourg I, 159 pages

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